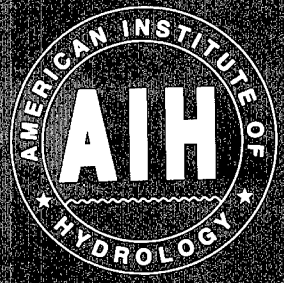
Fourth USA/CIS Joint Conference

Hydrologic Issues of the 21st Century: Ecology, Environment and Human Health

November 7-10, 1999, San Francisco, California



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John A. Apps
Chin-Fu Tsang

American Institute of Hydrology
1999

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1999 ANNUAL MEETING
OF THE AMERICAN INSTITUTE OF HYDROLOGY
and
THE FOURTH USA/CIS JOINT CONFERENCE ON ENVIRONMENTAL HYDROLOGY AND HYDROGEOLOGY

Hydrologic Issues of the 21st Century: Ecology, Environment and Human Health

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American Institute of Hydrology

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Communications in regard to this publication should be sent directly to AIH, 2499 Rice St., Ste. 135, St. Paul, MN 55113-3724, Tel. (651) 484-8169, Fax (651) 484-8357, E-Mail: <AIHydro@aol.com> or the Web Site: <aihydro.org>

Supporters of the Fourth USA/CIS Joint Conference on Environmental Hydrology and Hydrogeologist, *Hydrologic Issues for the 21st Century: Ecology, Environment and Human Health*, and the 1999 American Institute of Hydrology Annual Meeting, held November 7 -10, 1999, at the Cathedral Hill Hotel, San Francisco, California.

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Foreword

Hydrologic Issues for the 21st Century: Ecology Environment, and Human Health is a continuation of joint meetings on the problems and solutions of mutual interest in environmental hydrology and hydrogeology in the USA and CIS (formerly USSR) organized by the American Institute of Hydrology (AIH) in cooperation with major governmental agencies, scientific institutions, and private organizations.

This is the fourth in a series of joint conferences that have been held in St. Petersburg, Russia; Washington, D.C.; Tashkent, Uzbekistan in 1990, 1993, and 1996 respectively. The purpose of this conference is the international exchange of ideas, information and technology, seeking to find solutions to help hydrologists interact with scientists and engineers as well as politicians, economists, and water managers throughout the world. It is a continuation of joint meetings on the problems and solutions of mutual interest in environmental hydrology and hydrogeology organized by the American Institute of Hydrology in cooperation with major governmental agencies, scientific institutions, and private organizations.

The conference is held in conjunction with the 1999 Annual Meeting of AIH. The objective of the conference is to promote a continuing forum for scientific and technical exchange among scientific communities, and government agencies of participating countries, and U.S. businesses in the environmental industry, and to encourage partnerships among research and educational institutions, regulatory agencies, and industry.

The conference was supported by the following organizations:

- U.S. Geological Survey
- U.S. Dept. of Agriculture
- U.S. Dept. of Energy
- U.S. Environmental Protection Agency
- U.S. Department of State
- Nuclear Regulatory Commission
- U.S. National Committee on Scientific Hydrology
- Univ. of Massachusetts
- Univ. of Nebraska
- Univ. of Wisconsin
- E.L. Montgomery and Assoc., Inc.

The technical program includes keynote speakers, plenary presentations, special sessions, invited and submitted papers in concurrent sessions, and poster presentations. Besides the concurrent technical sessions, special sessions will be convened on selected topics. including well-known CIS environmental sites such as the Mayak, Southern Urals, Russia, and Chernobyl, Ukraine; results from national or international cooperative studies of Russian sites within the CIS; nuclear waste disposal; deep well injection; permafrost; and technological developments in data management and data transfer. The program will also include field and cultural trips, exhibits, and the AIH Annual Business Meeting. Two major awards will be presented: the R.K. Linsley Award, and the C.V. Theis Award.

Our editors, John A. Apps and Chin-Fu Tsang, have done an outstanding job reviewing and categorizing more than 200 abstracts and designing a comprehensive technical program. Helen Klose and Kat Wentworth assisted them in the laborious work of compiling, organizing and verifying the abstracts. We thank all of them and recognize the conscientious and energetic efforts put into such a formidable task. We would also like to recognize the efforts of all of the Organizing Committee members and delegations from the contributing countries. For many the tremendous efforts required to attend this conference demonstrate the very strong dedication that continues to characterize the contributors to this series of Joint Conferences. We would like most importantly to recognize the guest speakers and authors for their work which provides the substance for this important productive conference.

John D. Powell
General Chairman
4th Joint Conference on Environmental Hydrology and Hydrogeology

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For Publication Only

1999 C.V. Theis Award

The American Institute of Hydrology (AIH) established this award in 1986 to honor the charter member of AIH, C.V. Theis - the founder of modern ground-water hydrology. The award is presented annually, on the recommendation of the AIH Awards Committee, for a major contribution to the field of ground-water hydrology. The first C.V. Theis Award was presented to Roger J.M. DeWiest at the AIH Conference on Application of Recent Advances in Hydrosciences in San Francisco on March 26, 1987.

Citation: Marvin (Nick) Saines

It is an honor and a pleasure for me to be selected as the citationist for David Keith Todd to receive the *C. V. Theis Award* for 1999 from the American Institute of Hydrology. This award, presented annually since 1986, recognizes individuals who have made major contributions in the field of groundwater hydrology. It is entirely appropriate that this award should go to David because his contributions include his work as a teacher, a researcher, an author, and a consultant in the field of groundwater. Almost everyone working in the groundwater field is aware of his textbook, *Groundwater Hydrology*, first published forty years ago this year. This book described in an understandable manner the entire science of groundwater hydrology, ranging from the occurrence, movement, hydraulics, and quality of underground water to specialized topics such as sea water intrusion, artificial recharge, perennial yield, and investigational methods. The book has been published in two editions and translated into six foreign languages, making it the most widely used book in the field.

David's professional career spans more than four decades, beginning in the late 1940s, when the subject of groundwater was almost entirely a monopoly of the U. S. Geological Survey. He is unique in that at that early time he essentially decided to become a hydrologist. However, fate had something to do with his decision. He had completed only one year as a student in civil engineering at Purdue University in 1942 when he enlisted in the meteorology training program of the U. S. Army Air Corps. The crash program was started because of the dramatic shortage of weather forecasters in World War II. After completing his training he served as a weather officer at air fields in this country and overseas. Returning to Purdue he graduated with a B.S. in civil engineering in 1948 and, combining his two backgrounds, began working as a hydrologist with the U. S. Bureau of Reclamation. After a leave of absence to earn an M.S. degree in meteorology at New York University in 1949, he was invited to join the civil engineering faculty of the University of California, Berkeley. Here he obtained a Ph.D. degree in
1953 and developed a teaching and research program in water resources engineering - and served the university for 31 years. He also worked part time for the USGS from 1954 to 1956.

It is interesting to note that Ray Linsley, who is recognized by AIH with an award in his name for contributions in surface water hydrology, came to Stanford University just six months before David came to Berkeley. These two men divided the science of hydrology between themselves and established two of the major educational centers in hydrology in the United States. Many of today's leaders in groundwater hydrology studied as students under David Todd at Berkeley, including such well known names as Jacob Bear, John Cherry, Allen Freeze, and Shlomo Neuman.

The research efforts undertaken by David include work on dispersion in porous media, artificial recharge, sea water intrusion, and radioactive tracers, resulting in some 120 technical publications. He authored the first publication by the U. S. Geological

Survey on artificial recharge of groundwater. His massive reference book, *The Water Encyclopedia,* first published in 1970, has proven to be an invaluable source of data in the water resources field, and in its current edition is undoubtedly the heaviest book in any hydrology library.

With his unsurpassable academic and professional qualifications, David has, of course, been much in demand as a consultant on groundwater problems. In reviewing his resume I counted twenty-three foreign countries where he has been involved in hydrologic studies of one type or another. During the Kennedy administration he was tapped by the White House as part of a team to evaluate and recommend a solution for
the waterlogging and salinity problem of the irrigated lands in the Indus Valley of Pakistan. In the early 1970s, after creation of the U. S. Environmental Protection Agency, he prepared some of the earliest reports for the agency on monitoring wells and contaminated groundwater. More recently he assisted in developing a water supply for a new copper mine in northern Chile, one of the driest regions on earth.

David has accumulated recognition from a variety of sources for his professional accomplishments in hydrology. He is unique in having been named a fellow by four professional societies: the American Society of Civil Engineers, the American Geophysical Union, the American Meteorological Society, and the American Association for the Advancement of Science. The National Science Foundation granted him two post-doctoral fellowships; Purdue University named him a distinguished alumnus; and on the other side of the world, the American University of Beirut named him a Centennial Professor. In recent years the National Groundwater Association of California presented him with its John Hem Award, the Groundwater Resources Association of California
gave him its Lifetime Achievement Award, and of course our own American Institute of Hydrology named him an Honorary Board Member in 1997. David was one of the first supporters of the AIH, and joined in 1986.

Since retiring from the University of California in 1980, David has remained actively involved with a small consulting firm he founded in the San Francisco Bay area in 1978, Todd Engineers. As might be expected, the firm specializes in the planning, development, management, and protection of groundwater. But in spite of a busy schedule, he still makes time for ski vacations in Colorado and at Lake Tahoe, gardening with Rolly, his wife of 51 years, preparing Italian gourmet meals, and has recently taken up the game of golf, which he tells me is the most challenging undertaking of his life.

There is probably no other hydrologist in the world more deserving of the American Institute of Hydrology's *C.V. Theis Award* than David for a lifetime of contributions to the science and to the profession. Speaking on behalf of the members of the American Institute of Hydrology on the eve of the 21st century, I offer congratulations on this award to Dr. David Keith Todd - one of the giants of 20th century hydrology.

1999 C.V. Theis Award

Response: *David Keith Todd*

Recognition by one's peers is always satisfying and this is certainly true this evening upon my receipt of the C. V. Theis Award from the American Institute of Hydrology. The field of hydrology and groundwater in particular has always been fascinating to me. Enjoying what one does as an occupation or a profession not only makes work less stressful, it also makes it a pleasure. I was introduced to the science of hydrology as an undergraduate at Purdue University more than fifty years ago Because of my interest, Professor Frederick Greve, who taught hydraulics and hydrology there, suggested that I enroll in an individual study course on artificial recharge of groundwater. After that I was hooked on the subject.

One of the great things about working in the hydrology field is that it cuts across so many activities of the modern world. Water is everywhere, water is essential to all of us, and as a result everyone has some interest in the subject. So often in mentioning my field of interest to persons while traveling or on socia1 occasions, there is an immediate response and we can share a topic of common interest, whether it involves a backyard well, the sinking of the City of Venice, or the environmental impacts of chemicals on water supplies.

Looking back over the last half century, progress in hydrology has been neither steady nor gradual; it can only be characterized as dramatic. Everywhere one finds new developments, new reports, new publications, new organizations, and new people. Consider for example the topic of water quality. Initially we focussed solely on salinity and coliform bacteria; the numerous organic compounds known today as contaminants went unrecognized because their toxicity and their presence in groundwater has not been discovered. It took the creation of the U S. Environmenta1 Protection Agency in the early 1970's and the Love Canal disaster shortly thereafter to make us aware of what had unknowingly been happening to groundwater. The solvent, trichloroethylene, which has been in use since early in this century, was found almost overnight to be a potential carcinogen and a ubiquitous contaminant in groundwater. The only good that can be said about subsurface contamination is that it has stimulated widespread interest in groundwater, has augmented research and educational programs in the field, and has brought many new professionals into groundwater.

I wish to emphasize that whatever I have accomplished in hydrology has been with the help and stimulus of many other persons—professors, graduate students, and colleagues In 1956, the International Association of Scientific Hydrology organized the Darcy Symposium in Dijon, France, to make the centennial of a book on the water fountains of Dijon by Henry Darcy, a water supply engineer for that city. In a small appendix at the end of his book is a report on laboratory studies he had undertaken which defined a relationship we now call Darcy's Law. I was fortunate enough to participate in that meeting and met a large number of persons from European countries and the Soviet Union, all of whom shared my interest in groundwater. It was an invigorating experience and at that early time in my career I felt part of a group working on a shared goal. Surely this same spirit of camaraderie and belonging prevails among members attending this international meeting.

I would also be remiss not to acknowledge the fact that many individuals in the Groundwater Branch of the U. S. Geological Survey in my early days acted as advisors and mentors in helping me organize the graduate program in water resources at Berkeley.

Looking ahead, we are about to enter a new century and given all the progress of twentieth century, we all must wonder what to expect in the future for hydrology. Given the role of computers in storing, processing, and transmitting information, hydrology will play an increasing role in aiding mankind to solve all types of water problems and needs. With regard to groundwater I have been asked several times what will happen as we finally bring groundwater contamination under control. My response has been that groundwater will become increasingly important. We have nearly reached the limit in surface water reservoirs, but we have only begun to develop and manage our groundwater reservoirs. Water supplies will invariably become increasingly short, costs will rise, and the potential for increased resources rests in managing, recharging, and recycling water in aquifers.

Finally, I want to thank the members of the American Institute of Hydrology who saw fit to present this award to me. This shall remain a red letter day for the rest of my life. Thank you.

1999 Ray K. Linsley Award

The American Institute of Hydrology(AIH) established this award in 1986 to honor the first Vice President of AIH, Ray K. Linsley - one of the truly great leaders in the hydrological sciences. The award is presented annually, on the recommendation of the AIH Awards Committee, for major contributions to the field of surface water hydrology. The first Ray K. Linsley Award was presented to Peter O. Wolf, at the AIH International Conference on Advances in Ground-Water Hydrology in Tampa, Florida on November 17, 1988.

Citation: Stephen J. (Steve) Burges, University of Washington

It is my privilege and honor to introduce the recipient of the 1999 Ray K. Linsley Jr. Award, Professor Emeritus Peter S. Eagleson, from the Massachusetts Institute of Technology. Ray and Pete both have influenced the profession enormously. I am delighted that the names of two of my heroes are now linked formally through the AIH Linsley Award.

Ray was my doctoral advisor at Stanford. His mentorship did not stop with my graduation in 1970. He was always available for advice; he was a strong supporter and inspiring friend. He was one of the clearest thinkers I have known and one of the rare academic leaders who saw where science, society, and the practice of engineering combined. In addition to his leadership in hydrologic education, research, and practice, he built the program on Engineering Economic Planning (EEP) at Stanford in the early 1960s to provided educational and research direction in public works planning. The major thrusts of the EEP program were in water resources and transportation.

I first met Pete in November 1973 when I was visiting MIT. He too has been a strong supporter and inspiring friend. In 1973 he was head of the Department of Civil Engineering where he had built up an extraordinary interdisciplinary faculty team to approach issues of complex water resources systems. This group covered similar ground to the Stanford group, but with some different emphases. What distinguished both groups was the attention to the important roles of physical, chemical, biological, and policy sciences, including law, in water resources. Some of the most influential hydrology and water resources professionals of my generation graduated from the programs that were established by Ray and Pete. Ray and Pete have many academic "great grand children" in that their graduates have taken leadership positions in academe and their graduates have produced exceptional academic leaders who have produced a new generation of academic leaders.

Professor Eagleson is the Edmund K. Turner Professor of Civil and Environmental Engineering, Emeritus, and Professor of Earth, Atmosphere and Planetary Sciences, Emeritus, at MIT. He earned his B.S. in 1949 and his M.S. in 1952, both in Civil Engineering, from Lehigh University. He earned his Sc.D. in Civil Engineering from MIT in 1956. His scientific and professional career has been spent at MIT

Professor Eagleson has been honored on numerous occasions for some of his many scientific contributions and for his intellectual, scientific, and professional leadership.

His awards include: the Desmond Fitzgerald Medal, and the Clemens Herschel Prize of the Boston Society of Civil Engineers; the Huber Research Prize of the American Society of Civil Engineers; the Robert E. Horton Award, the Robert E. Horton Medal, and the William Bowie Medal (the highest award) of the American Geophysical Union; the International Hydrology Prize, International Association of Hydrologic Science; and the 1996 "Stockholm Water prize".

Each Year MIT honors on of its best colleagues with the James R. Killian Jr., Faculty Achievement Award. Professor Eagleson received that prestigious award in 1992-93 *for .. "extraordinary professional accomplishments.."*

He is a Fellow of the American Geophysical Union, the American Association for the Advancement of Science, and the American Meteorological Society. He was elected a Member of U.S. National Academy of Engineering in 1982, *"For Leadership in the theoretical foundations of modern hydrology"*

Professor Eagleson has given much to the profession through his published work, including his path breaking 1970 book "*Dynamic Hydrology*", and championing of colleagues of all ages and experience. He has provided extraordinary leadership to scientific and professional societies. Examples of his leadership include: President, Hydrology Section, 1982 to 1984, and President 1986 to 1988, of the American Geophysical Union. He was a founding member of the National Research Council's Water Science and Technology Board, from 1982 to 1986, and he chaired and provided the intellectual leadership of the Water Science and Technology Board's Committee on "Opportunities in the Hydrologic Sciences" from 1987 to 1990. That committee report has been the guiding framework for much of hydrologic research in the last seven years. He served on the NRC Commission on Geosciences, Environment and Resources from 1988 to 1994 and on the Board on Global Change from 1991 to 1993.

By any measure Professor Eagleson is a giant of the profession as was the late Professor Linsley. Linking the names Eagleson and Linsley adds luster to the prestigious Ray K. Linsley, Jr. Award, and shines the spotlight on the American Institute of Hydrology.

1998 Ray K. Linsley Award

The American Institute of Hydrology (AIH) established this award in 1986 to honor the first Vice President of AIH, Ray K Linsley - one of the truly great leaders in the hydrological sciences. The award is presented annually, on the recommendation of the AIH Awards Committee, for a major contribution to the field of surface water hydrology. The first Ray K Linsley Award was presented to Peter 0. Wolf at the AIH International Conference on Advances in Ground-Water Hydrology in Tampa, Florida on November 17, 1988.

Citation: *David R. Dawdy*

It gives me great honor to have my good friend, Jim Dooge, receive the Linsley Award of the AIH. I first met Jim in 1964 when, appropriately, he was visiting Ray Linsley and stopped by Menlo Park to see Terence O'Donnel, then of Imperial College, who was working with me for a year on rainfall-runoff modeling. Jim was eager to explain his latest work to us, and started to write enthusiastically on the blackboard, which was lightly attached to our partition. The blackboard fell to the floor, but Jim never missed a stroke or a word as he dropped to his knees and continued his lecture. That is typical of the enthusiasm of Jim. That enthusiasm, his great insights into the problems of surface water hydrology, and his immense political skills have made him a leader in the field, and very deserving of the Linsley Award.

After 15 years in the Civil Service, Prof. James C.I. Dooge moved to University College, Cork for 12 years, then to University College, Dublin, from which he retired in 1984. Retired is not the word for Jim, though. He was a visiting professor at University College, Galway, for three years, then returned to Dublin as a Research Consultant. In between all this Jim was a member of the Irish Senate from 1961 to 1987, was the Minister for Foreign Affairs and then Government Leader in the Senate from 1983 to 1987.

Jim was instrumental in setting up the Committee on Mathematical Modeling of the IAH. He was Chairman and I was Secretary. I remember an official meeting of our Executive Committee with Jim, me, and Nathan Buras, Vice President, with a bottle of champagne over lunch on the square of a Spanish village on a trip from Madrid to Seville. I'm sure
there are minutes of that meeting, but after a bottle of champagne who cares? That committee was typical of Jim's efforts to introduce modern methods into hydrology, and it evolved into the International Commission on Water Resources of the IAHS. Jim believed in communication between East and West, so we organized symposia on mathematical modeling in Budapest, Prague, Bratislava, Warsaw and Moscow.

Jim's paper "A General Theory of the Unit Hydrograph" in Water Resources Research in 1059 placed unit hydrograph analysis in the general field of linear systems analysis. He received the Horton Award from the American Geophysical Union for the paper, and it set the tone for research for a decade or more in surface water hydrology. Jim has published some 140 papers over the 50 years from 1947 to date. Jim also has received many other awards, including the Ven Te Chow award of ASCE and the Bowie Medal of the AGU.
He is an Honorary Member of many societies around the world, and a few of many more. These include the ASCE, AGU, Institution of Civil Engineers (London), and the Collegium Ramazzinu (Bologna). He was President of the IAHS in 1957 to 1979, and received their International Prize for Hydrology in 1983.

1998 Ray K. Linsley Award

Response: *Jim Dooge*

When I graduated as a Civil Engineer 57 years ago there were no courses in hydrology and no standard textbooks or works of reference on the subject. Hydrology in the modern sense did exist, however, in the U.S. due to the efforts of such pioneers as Horton and Langbein and the meetings the hydrology section of AGU and in other countries due to a small number of their contemporaries and counterparts. Nobody epitomizes the change to a more systematic approach to the teaching and practice of hydrology than Ray Linsley. Because of my debt to him during my early learning years as a hydrologist, I feel particularly honored to receive this award which commiserates his memory. We all owe a great deal to his leadership.

The pleasure of the occasion is enhanced by the presence of Oleg Vasiliev whom I first met in 1961, Pete Eagleson whom I first met in Leningrad in 1965 and Dave Dawdy with whom I founded the Committee on Mathematical Models in Hydrology in 1967. I think it can be claimed with justification that the latter committee provided an appropriate vehicle for a revolution in hydrologic thinking.

The years since then have been interesting for me personally and for the subject of hydrology. Despite the burdens of political office and the concerns as head of a broad civil engineering department, I have found time and energy to maintain my interest in hydrology, which was first aroused, when I was faced with practical problems in river improvement works and hydro-electric design. From time to time a fellow hydrologist has asked me: "What is your ambition for hydrology as a subject?"

To this I would usually reply: "I hope to see hydrology recognized as a science before I die." To those of you of the younger generation I make this appeal: "Will you please contribute to this effort. I haven't that much time left".

Why do I think theory is important? Good theory makes it so much easier to ensure good practice. In this final year of the International Decade for Natural Disaster Reduction, it is appropriate to reflect that good theory is essential for forecasting and mitigating the impact of water-related disasters. Progress, both theoretical and practical, is easiest to achieve when there is real dialogue between the two worlds of speculation and application. But it must be a real dialogue and not a dialogue of the deaf, not the dialogue typical of a cocktail party.

For such a dialogue to be fruitful, it must be concerned with a genuine common interest; it must be focussed on a real problem rather than on generalities; it must avoid all ambiguity of language and weed out dangerous differences of definitions; it must be based on parity of esteem for the other's concerns and expertise; and above all it must involve an ability and a willingness to listen as well as to talk. Such a real dialogue is not only necessary between these two groups but within the groups and also with the various stakeholders among the general public.

Having advised you to listen as well as talk, I should follow my own advice. My final words are to the effect that I have enjoyed my work as a hydrologist - it was often hard but it was also fun. I am glad to have done what I did. I am glad to be here tonight. Thank you Mr. President, thank you members of AIH for the honor you have done me.

Honorary Member of the AIH Advisory Committee

GERALD T. ORLOB

Citation: *Miguel A. Marino*

Or. Orlob, a native of Washington State, has been a resident of Californla throughout most of his career. His professional experience has been divided about equally among engineering education, research, and consulting practice. He holds BS and MS degrees from the University of Washington in civil and environmental engineering and a Ph.D. from Stanford University in hydraulic engineering. For thirteen years he was a member of the civil engineering faculty of the University of California at Berkeley where he engaged in teaching and research concerned with the development and application of mathematical models and systems analysis techniques for environmental management, primarily focused on the hydrologic, hydromechanical and water quality behavior of surface water systems--rivers, lakes, reservoirs, estuaries, and coastal waters.

In the mid 196Os Dr. Orlob became chief executive officer or Water Resources Engineers, inc. (WRE), a consulting firm he founded that came to be recognized nationally and internationally as a leader in the development of mathematical models for water management. Original models developed by WRE under his direction include the stream water quality model, QUAL 2E; the storm water management model, SWMM, the river-reservoir system model, WQRRRS; the lake autrophication model, LAKECO; the Bay-Delta Link-Node Models for estuarine hydrodynamics and water quality; and finite element models for two and three-dimensional simulation of lacustrine ard estuarlne systems. Some of these models are currently in wide use, both nationally and internationally, by governmental agencies and consulting firms for assessment of environmental impacts of water resource development and pollution control strategies.

Dr. Orlob is the author of more than 200 technical papers; reports, and rnonograph contributions on systems analysis, mathematical modeling, water quality management, and other topics in environmental engineering, hydrodynamics, hydrology, and water resources. He has received the Karl Emil Hilgard Hydraulics Prize, the Rudolph Hering Medal, and the Julian Hinds Award from the American Society of Civil Engineers, the Resources Division Award of the American Water Works Association, the Harrison Prescott Eddy Award of the Water Environment Federation, and the Hydrology Section Award of the American Geophysical Unlon for his published research contributions. His current research is focused on mathematlcal modeling of hydrodynamics, water quality and ecology of natural aquatic systems, design of computerized support for environmental decision making, interactive computer graphics and animation, and effects of climate change on aquatic ecosystems.

Dr. Orlob serves as a consultant to private and public corporations, local, state, and national agencies, and international organizations; e.g., UNDP, UNEP, WHO and FAO, on matters concerned with water quality management. From 1992 to 1996 he served as a rnember of the Mamala

Bay Study Commission to direct a major water quality investigation of the coastal environment of Honolulu. Currently, he serves as Chair of the International Science Advisory Committee on water research for the Technion, Israel. Dr. Orlob is a registered civil engineer in California, a Diplomate of the American Academy of Environmental Engineers, a Certified Hydrologist by the American Institute of Hydrology, an Honorary Member of the American Society of Civil Engineers and a member of the National Academy of Engineering. At present he continues an active program of research at UC Davis.


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Plenary Session

The Modern Tendencies in Nuclear Waste Management and Waste Disposal in Deep Geologic Formation in Russian Federation

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Conception of nuclear waste and spent fuel management in Russian Federation is under development now. The work on the conception is almost done. The final stage of life cycle of nuclear waste and spent fuel which can not be reprocessed is waste disposal in geological formation.

Spent fuel of PWR-440, PWR-1000 and LMFBR-800 reactors will be reprocessed for obtaining of new fuel for Atomic Power Stations. The problem of reprocessing of spent fuel form BWR reactors is still under solution. One of possible way of this spent fuel management is its temporary holding in a surface repository with possibility of disposal in deep geological formation in future.

The main steps and stages of waste management for different types of nuclear waste are reported in this presentation. The role of liquid waste disposal in deep geological formation is discussed. This method of waste disposal is used in Russian Federation from 1963 and it is planned to terminate all injections of nuclear waste the beginning of next century. Conservation of the injection sites is complicated problem that is under research now.

Investigations for disposal of solid wastes in geological formation now are carried out at the New land Island, in the Krasnoyarsk region and in South Ural. Also a number of regional wastes repositories are under construction now. In the presentation the concepts op repositories and main result work already done is discussed.

Contaminant Assessment

Delineation of PCB Contaminated Soil Using Immunoassay Field Test Kits Launch Complex 36, Cape Canaveral Air Station, Florida

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Under the direction of NASA-Kennedy Space Center, immunoassay field test kits were used during a RCRA Facility Investigation at Cape Canaveral Air Station, Florida, as a rapid and cost effective method for the delineation of PCB contaminated soil. The goal of the soil investigation was to delineate the extent of soils containing PCB concentrations greater than I mg/kg at Launch Complex 36. A total of 240 surficial soil samples were collected and analyzed for total PCB concentrations using the Ensys, Inc. PCB RISC® Soil Test System which employs EPA Method 4020.

A total of 153 of the 240 field analyzed samples (64%) were sent to a fixed laboratory for confirmatory analysis using EPA Method 8081. Approximately 85% of the field results matched the laboratory results. The chi-square test of independence was used to analyze the data, and the results indicate a definite correlation between the field and laboratory data sets. Discrepancies between the field and laboratory data may be related to difficulties encountered when quantifying multiple PCB congeners detected at or near the laboratory reporting limit.

Although the cost of each field test (including all supplies and equipment rental) was approximately 25% less than traditional laboratory analysis, the cost of field labor time must also be accounted for when using the field test kits. The major advantage of soil delineation using field test kits is the ability to complete the delineation in one field phase using real time data, rather than a series of phases dependent on the fixed laboratory results.

Ground-Water Quality along a Flowpath in a Surficial Glacial Aquifer in the Upper Mississippi River Basin-The Influence of Land Use

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The quality of ground water along a flowpath in a surficial (glacial) aquifer in the Twin Cities (Minneapolis-St Paul, Minnesota Metropolitan Area) was characterized as part of the U.S. Geological Survey's National Water Quality Assessment in the Upper Mississippi River Basin. The aquifer has a water table within about 20 feet of land surface, hydraulic conductivity ranging from 0.014 to 990 feet per day, and relatively low organic-carbon content that ranged from 0.10 to 41 grams per kilogram. These aquifer characteristics typically are associated with increased susceptibility to leaching of fertilizers, pesticides, and other organic substances from land surface.

The study indicates that the surficial aquifer underlying the northwestern Twin Cities metropolitan area is a complex and dynamic system. Water in the aquifer naturally contains substantial concentrations of iron and manganese and has been affected by

leachate from road salt. Anthropogenic contaminants, including nutrients, pesticides, and volatile organic compounds occur in the aquifer, many of which are removed by naturally occurring processes. Land use overlying the surficial aquifer is related to hydrologic features in the area. Residential and industrial areas are concentrated in the better-drained upgradient portion of the flowpath. In contrast, parks and wetlands predominate in the downgradient portion for the flowpath where the water table is closer to land surface. Acetone and bromide were detected in greater concentrations near roadways than in areas away from roadways, possibly due to their emissions from the combustion of gasoline. The widespread occurrence of prometon, a long-lasting herbicide, is more closely related to applications in parks, rather than to road right-of-ways in the area.

Hydrogeologic Investigation of Multiple Contaminant Plumes at the Ellsworth Air Force Base, Rapid City, South Dakota

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Ellsworth Air Force Base, located outside Rapid City South Dakota, has completed studies to determine the origin and movement of multiple plumes of volatile organic compounds detected near the northeast portion of the base. Groundwater monitoring had shown the presence of contamination over a widespread area and lead to concern for multiple contaminant sources both on- and off-base. These plumes impact private water supplies and, therefore, determining their origin was critical to achieving a remedy. Site studies were initiated to learn if the origin of the various plumes is common and to find potential pathways and receptors. Both surficial watershed boundaries and subsurface ground watershed boundaries were delineated, and recharge and discharge areas were identified to define the physical constraints for water flow. The studies have shown that the boundaries of the two watershed types generally do not coincide. A complex hydrogeologic system was delineated with three main controls on ground water flow: the presence of the terrace sand and gravel deposits, the pattern and distribution of the buried paleochannels, and the presence of a discrete network of highly conductive "open framework gravel beds." The paleochannels were carved in the Pierre Shale surface and filled with coarse alluvium of the Rapid Terrace. Although this coarse alluvium covers the entire network of paleochannels, the water table in many areas is below the buried shale ridges that separate the paleochannels. The presence of paleochannels was documented by seismic refraction data. The presence of "open framework gravel beds" was inferred from the fact that site contaminants migrated much faster and further (5.5 miles) than could be deduced from a site measured hydraulic conductivities and gradients. Contaminated groundwater has been shown to migrate in the paleochannels that cross the overlying surface drainages created during the Post-Pleistocene period. Groundwater discharge is controlled by headward erosion of surface drainages that have exposed the paleochannels. The investigative techniques employed delineated two distinct contaminant plumes, defined the bedrock paleosurface, and identified private water supplies likely impacted by base activities. These findings served as a basis for planning the response actions to contain and control contaminated groundwater before it leaves the base. Computer simulations were completed using MODFLOW and MT3D. The

models were developed to evaluate the operating site remediation system, verify and refine the conceptual model for the site hydrogeologic setting, and to predict the rate of plume dissipation after employment of the remediation system. The model output was also helpful in deciding whether providing an alternative water supply to off-site receptors is necessary.

Contaminants Modeling in a Quarry

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Surface waters toxics pollution control requires an adequate knowledge of transport and transformation phenomena, which address these substances to their final fate.

Thus, water quality simulation models are largely applied in waste-load allocation studies, environmental impact investigations and, more generally, in cause-effect relationship analysis for toxic contaminants in a water body.

The Water Quality Analysis Simulation Program (WASP) is a dynamic compartment modeling system developed by US EPA to study water quality problems in streams, lakes and estuaries; WASP could be applied both to conventional and toxic pollutants using, respectively, EUTRO and TOXI models.

In this paper TOXI5, which is not largely used as EUTRO model and, thus, is less verified in field situations, has been tested applying it to a case study in a flooded limestone quarry located in Bedford County, Indiana. This quarry has been polluted with equal quantities of the insecticides DDE and Lindane. Data field of water column and bed sediments contaminants concentrations along 5 years has been provided by the Waterways Experiment Station (WES) of US Army Corps of Engineer, which has previously studied this case using RECOVERY model. TOXI5 model results show a good agreement with field observations; particularly, model results point out the different removal mechanism for DDE and Lindane. The former one is subjected to volatilization and photolysis and, being a more hydrophobic compound, tends to be removed by solids settling; on the contrary, the latter, which is more polar and has lower volatilization rate, tends to remain for a longer time in the water column.

Remotely Accessible Information Systems: A Superfund Case Study

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Records for many sites where federally mandated clean up activities have taken place have accumulated up to twenty years of sampling data and site records. Typically, there is no complete comprehensive spatial and tabular database with site information fragmented among paper copies and various electronic formats. This results in limited accessibility and usefulness. Organizing and transferring the relevant database or information to the various parties involved in site characterization, remediation, and redevelopment becomes problematic, particularly in a format conducive to customized data analyses.

Developing a remotely accessible centralized database provides a means of maximizing the data utility for state and federal agencies, site contractors, and site personnel. A geographic information system provides the user interface and framework for data interaction through mapping and querying capabilities. The entire application may be designed to be remotely accessible using a Web browser, or customized user interface. Once implemented, the Web application provides controlled maintenance of data, an efficient means of sharing all or part of the application database, and 24-hour user access.

The application for the Superfund site considered in this case study was developed from data collected over a period of approximately two decades. Tabular data from paper copies were the primary source of historical data, while more recent data were contained in electronic databases of various formats. Quality assurance and quality control checks were performed on all data entered into the databases from paper copies and electronic files. Database development included developing spatial data (maps) and tabular data (e.g., analytical data) and constructing relation links between the spatial and tabular data. To enhance application performance, large files such as maps and documents were installed on the local computer, and the tabular data queries were performed over a secure internet connection.

Drinking Groundwater Pollution in Kazakhstan

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The pollution of drinking groundwater in Kazakhstan is a rather serious problem. 343 drinking water well-fields, operate in present time, from total 343 which were prospected. The pollution of a various degree of danger takes place on 113 of them. The heavy metals pollute 20%, nitrates - 26%, oil-product - 10% well-fields. The pollution by mercury both heavy metals of an extremely dangerous and dangerous degree is usually for most of drinking groundwater well-fields of the Karaganda and East Kazakhstan industrial areas.

The estimation of a condition of drinking groundwater reservoirs, at a regional level, is given for the main of a drainage basins: the Caspian and Aral seas basins, the Balkhash lake basin, the Irtysh river basin, and also for the Central-Kazakhstan region. The

drinking groundwater exploitable resources are concentrated in limits Balkhash (40%), Irtysh (26%) and Aral (18%) regions. Only 19% of groundwater resources were prospected for Caspian and Central-Kazakhstan regions.

The nitrate pollution of drinking groundwater is typical for Balkhash and Aral regions in the greater degree, the oil-products pollution -for Caspian, the heavy metals pollution - for Irtysh and Central-Kazakhstan regions, in general depends on features of technogeneous in regions. The tendency of the further development of groundwater pollution of Kazakhstan is observed. The basic reasons of it are:

- mineral operators not take measures for the prevention and liquidation of pollution,
- the environmental legislation and mechanism of it influence are elaborated imperfectly, especially in a part of the responsibility of the enterprises-pollutants,
- using technology of enterprises is ecologically imperfection.

Practically, complete absence of struggle with technogeneous pollution of groundwater can result in rather heavy consequences - the population of a number of areas of Kazakhstan in the future can appear without fresh drinking water.

Problem of Technogeneous Pollution of Aquifers with Oil-Products in Kazakhstan

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The pollution of groundwater, soil and aeration zone by oil-products represents a rather serious technogeneous problem. Sources of such pollution are oil-well fields, oil refining enterprises, objects of a storage and transportation of fuel. The pollution of geological environment occurs as a result of emergency and technological leakages, oil-spills on a surface of ground, etc. Therefore, the significant quantity of hydrocarbons accumulates in an aeration zone of aquifers, forming floating lenses on a surface of groundwater, partially dissolving in groundwater. Such pollution usually reveals in many years, when reaches significant sizes cause ecological catastrophes.

In Kazakhstan there are 3 oil refining plants, more than 12 thousand oil-reservoirs with volume of realization from 1 up to 500 thousand tons in a year and more. The sum total fuel losses on a filtration into aquifers are estimated in 480-870 thousand tons in a year in Kazakhstan. To the present time, taking into account of duration of oil-reservoirs operation, on adjacent to them territories in aquifers could accumulate from I up to 5 million tons of fuel. The biggest part of it should be near 230 largest oil-reservoirs. Such artificial oil-products accumulations, as a rule, lie on small depths as floating lenses with thickness of 0,5-1 m and more and occupy the areas from some tenth to a few sq. km. Extractable quantity of oil-product from such accumulations can reach tens and hundreds thousand tons.

Such accumulations can be formed only in favorable hydrogeological conditions. Therefore, realization of special hydrogeological investigations requires in each concrete Case. The available technology allows to extract fuel from a floating layer with it thickness more than 5 cm without an impurity of water.

Water Catchment Area as the Basis of Identifing Qualitative and Quantitative Objectives for Surface Waters

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Over last decades of the century a fundamental change in the character of forming resources and natural water quality has taken place, which is related to greater technological environmental impacts on catchment areas. Currently most pollutants get into water bodies not with wastewater, but rather from diffuse pollution sources, scattered over catchment areas. The scale of the diffuse discharge negative pressure on natural water quality can be much harder than the impact of the run-off under control in terms of many factors. However, at present scientific information on the laws, under which diffuse discharge is formed at catchment areas, is not sufficient, which in its turn does not permit to develop methods of regulating these processes. As a rule, water conservation measures to be taken within various projects aim at improving river channels and neighboring territories, rather than at improving the basin on the whole. These measures efficiency is negligible, being mainly accounted for by insufficient consideration of the diffuse discharge formed at water catchment areas. Regular control over the diffuse source pollutant delivery has not been organized, thus there is no possibility to completely and realistically evaluate cubic capacity of the discharge.

Difficulties resulting from the identification of diffuse pollution sources and the assessment of the pollutant volume account for the following features of these sources

- Their being scattered over water catchment areas;
- Non-static regime of the diffuse discharge (seasonal character);
- Diffuse discharge being mainly connected with hydrological phases of high water periods;
- Dependence of pollutant delivery on many factors (both natural and anthropogenic);
- Availability of buffer zone between the source of pollution and a water body;
- Great number of pollutants delivered from diffuse sources.

Among diffuse pollution sources, located in river drainage basins, the prior place is given to agricultural lands (due to the fact that they, as a rule, occupy vast areas).

Ammonia nitrogen, nitrate nitrogen, phosphorous, suspended solids, sometimes even salts are characteristic of hydro-chemical indicators of the discharge delivered into water bodies from agricultural drainage basins. The supply of nutrients from agricultural lands is one of the reasons why water bodies eutrophication is taking place, the latter becoming a global process. Due to this, when evaluating the contribution of different diffuse sources into the surface water pollution, it's important to start with quantitative evaluation of the mass of pollutants, discharged from agricultural drainage basins into water bodies.

The amount of pollutants discharged from agricultural and natural lands depends on a number of natural and anthropogenic factors. The most important among them is whether the basin under consideration belongs to this or that climatic zone as for each of the latter there are certain typical geological, climatic and soil conditions, which in their turn determine peculiarities of the vegetation and soil structure.

The inventory of the criteria to evaluate a water catchment area has been done, the former depicting the condition of a drainage basin both from the point of view of technological environmental impact and geo-ecological stability to resist this pressure. Multipurpose objectives - stability potential and the level of technological environmental impact - served as basic criteria for evaluating water drainage basins. Due to the mentioned above the methods for evaluating water catchment areas in terms of ecology

and water management were developed, they being the foundation for regulating agricultural and technological activities in river basins.

Chemistry and Ground and Surface Water Pollution of the Urban-Industrial Regions in the Tom River Basin (Western Siberia)

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The Tom River Basin is one of the most developed industrial regions of the Western Siberia. There are 3,7 million people on the area of 62 thousand km^2. 141 million tons of coal are mined yearly; the mining, chemical, metallurgical, ferrous, non-ferrous and nuclear-chemical industries are developed here. The average water runoff of Tom River equals 1130 m^3/s, runoff intensity is 18 l/s km^2, 2,5 billion m^3 sewage are drained in the river yearly. In the region 3,4 billion m^3 of water is used annually including 2,6 and 0,7 billion m^3 of surface and underground waters accordingly. The potable water portion is 18% from total consumption.

We have carried out a vast investigation to estimate an ecological-geochemical state of the underground and surface water in the Tom River Basin. About 300 water samples have been taken and analyzed. All possible main and trace elements, ions, metals, gases, organic compounds, microorganisms have been analyzed in these samples. Unstable components have been analyzed immediately just by the spring.

Obtained data show that strongly contaminated water occurs in limits of developed industrial areas (towns, farms, mines and so on). The industrial contamination of rivers is found everywhere. An atmospheric contamination takes the great part to diffuse contaminants on the area and covers almost all territory in different degrees although its values are insignificant in most cases. The organic contamination from an oil and a coal is spread most extensively in the surface and underground waters. Even waters from underground sources contains this kind of contamination. Others types of contamination occur on limited territories.

The main conclusion confirmed with facts is what that an active water-changing being typical for the region hinders it's strong (catastrophic) contamination.

Reducing Hydrologic Impacts of Mines in Mountain Areas of the Western U.S.

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Mining was the driving force of the initial development of many mountain ranges in the American West. The intense alteration of portions of the mountain landscape led to severe changes in water and sediment rebates many western rivers. Recovery is still progressing more than a century after the initial disturbance. Major water quality problems related to mining predated statehood in many areas. Some long-abandoned

mines and waste piles continue to pollute mountain streams. Water management structures and legal systems are other enduring legacies nineteenth-century mining in the western states.

Mining continues to be an active land use and potential pollution source in various mountain regions of the West. Although regulation and technology have greatly reduced the release of mining-related contaminants into streams and lakes, the larger-scale of some operations creates great risk of catastrophe in the event of failure of pollution control techniques. Some small-scale mines operate outside of legal or regulatory control and are responsible for severe local problems. Modern mine-related pollution is superimposed upon the persistent impacts from abandoned mines, leading to a cumulative suite of impacts in some catchments or river basins.

This paper provides an overview of historical and current impacts of mining on water resources in mountain ranges of the western states as well as a summary of efforts at controlling pollution and rehabilitating abandoned mine sites. A novel regulatory approach to mine pollution recently adopted by Mono County in eastern California will also be highlighted.

Hydrogeoecological Problems of Diamond Deposit Exploitation in Arkhangelsk Region

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Primary diamonds deposit is located in western part of Belomoro-Kouloyskogo plateau and consists of 6 kimberlite pipes. Mining, geological and hydrogeological conditions of its exploration are rather complicated because country rocks are poorly cemented and intensively watered to the depth 220 - 250 m. Ecological problems arise firstly because the region of deposit is timbered with high qualited forest (including a reserved part), and rivers are the places of salmon spawning-grounds. Analysing the results of previously carried out researches it becomes possible to divide the deposit territory and its vicinities into 3 zones, according to the degree of hydrogeological and ecological impact of exploitation :

- Zone I of direct impact, appropriate to the area of mine and accompanied works;
- Zone 2 of direct influence on ecosystems. This zone is appropriate to the area of groundwater level changes, happening due to dewatering and water-removal systems;
- Zone 3 of indirect influence on the environment. This zone is appropriate to the area of secondary changes of ecosystems, which happens round zone 2, where the groundwater regime is undisturbed.

It is planned to construct a number of models on the basis of implemented zoning. These models must be of differ detailing level, depending on the zones. For information support it is planned to provide a special complex of eco-hydrogeologic researches. Prognosis calculations will be carried out not only to estimate piezometer heads and budget, but also for evaluation of depended elements; natural landscapes, surface and

aqueous ecosystems, marsh complexes, forests, vegetative communities. For such modeling the filtration and mass-transport programs (Modflow, Feflow) will be used, added with the program of ecological modeling NICHE.

Assessing Sediment Mobility in Suisun Marsh

Rik Lantz, Mary Gleason, and Craig Freeman

Contaminated sediments are present on the surface of a vital salt marsh in the San Francisco Bay. Assessing whether these sediments are mobile and may contaminate currently uncontaminated portions of the marsh or the San Francisco Bay is a critical question that requires resolution as the remediation of the marsh surface is considered. However, the complex dynamics of tidal marshes frustrate attempts to directly measure sediment movement as suspended solids. To overcome the difficulty of direct measurement, a scheme using several lines of evidence was devised to assess whether net sediment movement is into or out of the marsh. These lines of evidence include determining sediment accretion rates using palopalynology and lead-210 isotopic dating techniques, and long-term turbidity monitoring over many tidal cycles. The results of this work are expected to convincingly demonstrate that marsh surface sediments are relatively immobile, and that the potential threat of contaminating uncontaminated portions of the marsh and the Bay is modest.

Remediation: Physical, Chemical and Microbiological

Surfactant Enhanced Remediation at a Solvent Spill Site: Integration of Modeling and Experimental Studies in Pilot Test Design

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Surfactant enhanced aquifer remediation (SEAR) has been shown to be a highly efficient technique for recovering dense nonaqueous phase liquids (DNAPLs) in laboratory experiments. In field applications, however, the efficiency of surfactant enhanced solubilization can be adversely influenced by such factors as formation heterogeneity, density plunging, sorption, and solution rheology. Contaminant source accessibility may also hinder SEAR performance. This presentation describes the integration of experimental studies and mathematical modeling to optimize the design of a SEAR field demonstration for the recovery of free phase tetrachloroethylene (PCE) from an unconfined aquifer composed of glacial outwash deposits.

The proposed pilot test site is a former dry cleaning facility in Oscoda, MI. The contaminated aquifer has a saturated thickness of approximately 15 feet, is comprised of a fairly uniform fine to medium sand, and is confined below by a thick clay layer. Drive point samples, monitoring well data, and soil core information have been used to characterize the aquifer and determine the extent of contamination. Coring and grain size analyses suggest the presence of a coarse sand and gravel layer 11-16 feet below ground surface and a sand/silt/clay transition zone at the base of the aquifer. A narrow PCE plume emanates from the source area beneath the former dry cleaning facility and discharges into Lake Huron approximately 700 feet down-gradient. Plume centerline aqueous PCE concentrations range from a high of 88 ppm beneath the source zone to 10 ppm 500 feet down-gradient. Soil core samples have confirmed the presence of residual PCE within the coarse sand and gravel layer near the top of the saturated zone and have detected consistently high PCE concentrations at the base of the aquifer.

An integrated series of batch, column, and sandbox studies has been conducted with site aquifer material to explore the potential performance of various surfactant formulations for PCE recovery. Tween 80, a commercially available, nontoxic, biodegradable surfactant, has been selected as a cost effective and efficient solubilizer for site application. Experimental observations highlight the potential influence of interfacial tension changes, density variations, and solubilization mass transfer limitations on SEAR performance. Industry-standard three-dimensional groundwater flow and transport models are being employed to model Tween 80 delivery to the pilot test area in order to develop a surfactant injection scheme that effectively sweeps the suspected source region and restricts off-site surfactant losses. A laboratory-validated two-dimensional multiphase solubilization simulator is then being used, in conjunction with laboratory-measured parameters, to evaluate the design performance and to investigate the potential influence of small-scale heterogeneity, mass transfer limitations, and density variations on contaminant recovery.

Performance Evaluations at the Moffett Field and Department of Defense Permeable Barrier Sites

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A pilot scale permeable reactive barrier (PRB) or treatment wall demonstration project was initiated by the US Navy EFA West at the former Naval Air Station Moffett Field site in Mountain View, California, about 3 years ago. Performance evaluations and cost-benefit analyses were performed by the US Naval Facilities Engineering Service Center (NFESC) and were sponsored by the Department of Defense (DoD) Environmental Security Technology Certification Program (ESTCP). The Moffett Field PRB uses a funnel-and-gate design, where the funnel is made of interlocking steel sheet piles and the gate consists of a reactive cell filled with zero-valent granular iron. Since its construction in April 1996, groundwater monitoring was conducted on a quarterly basis to demonstrate the effectiveness of the barrier technology in capturing and remediating groundwater that contained dissolved chlorinated hydrocarbon compounds. The primary contaminants of concern at Moffett Field in the vicinity of the PRB are trichloroethene (TCE), cis-1,2 dichloroethene (cDCE), and perchloroethene (PCE) at upgradient concentrations of about 2900 micrograms per liter (ug/L), 280 ug/L, and 26 ug/L, respectively. Quarterly monitoring events included water level measurements, field parameter testing, and groundwater sampling at about 75 monitoring points. Two tracer tests using bromide solutions and flow meter testing were also completed in April and August 1997 at the site. Iron cell coring samples were collected and analyzed in December 1997 for use as indicators of reactivity and longevity. Data from the quarterly monitoring, tracer testing, and iron cell coring have been used to determine the overall barrier performance. Since the first sampling event in June 1996, concentrations of all chlorinated compounds were either reduced to non-detect (ND) or to below the drinking water maximum contaminant levels (MCLS) within the first 2-3 feet of the permeable iron cell (gate).

The iron cell coring analyses and geochemical modeling from Moffett Field indicated that changes in the inorganic chemistry were caused by precipitation of calcite, carbonates, iron-sulfide, and hydroxide compounds. Chemical precipitates are a significant concern because of the potential loss of reactivity and permeability in the iron cell. In general, long-term performance and life expectancies at PRB sites are unknown. The ESTCP, Environmental Protection Agency, and Department of Energy are sponsoring additional performance and longevity evaluations at multiple PRB sites across the country. This is being accomplished in partnership with the RTDF PRB Action Team in an effort to gain widespread regulatory acceptance and remedial project manager confidence in using the reactive barrier technology.

Electro-Kinetically Aided Restoration of Contaminated Soils and Groundwater

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Electro-kinetics, an emerging innovative technology, which utilizes electrical fields to drive fluids, ions, and charged particles through a porous medium, is starting to be used for in-situ soil and ground water remediation. The technology has previously been utilized stabilizing and de-watering unstable soils, dewatering muds, drying sludges, enhanced oil recovery, leach mining, and minerals recovery operations.

Electro-kinetics is a general term describing a variety of physical changes, electro-chemical reactions and coupled flows, which can occur when electrical current-flows through soils containing one, or more, phases of fluids. Major electro kinetic mechanisms are:

- Electro-Osmosis - movement of water through a porous matrix of charged solids under the influence of an electric field.
- Electro-Migration - movement of dissolved ionic components, such as anions and cations within an aqueous solution under the influence of an applied electrical field.
- Electro-Pboresis - movement of charged solid suspended particles (e.g., colloids) through a fluid under the influence of an applied electrical field.
- Electrolysis - decomposition of water into oxygen and hydrogen gases at the electrodes.
- Joule heating - heat generated by the passage of an electrical current through a conducting medium.

Electro-Kinetically Aided Remediation (ERAR) laboratory treatability testing (LTT) and pilot tests have shown:

1. one-three orders of magnitude increase in fluid flow rates through aquitard materials, offering promise of rapidly cleaning up these types of long-term aquifer contamination sources;
2. rapid recovery of fuels (e.g., BTEX), solvents (e.g.,' VOC), and poly-aromatic hydrocarbons (e.g., coal-tar residues) from fine-grained permeability (e.g., Kh < 10-6 cm/sec) soils;
3. rapid recovery of organic contaminants, using ionic surfactants from both high and low permeability soils;
4. rapid recovery of anionic contaminants (e.g., nitrate, perchlorate, etc.) from both low and high permeability soils;
5. rapid recovery of metallic contaminants (e.g., arsenic, cadmium, cesium', chromium, cobalt, lead, nickel, strontium, uranium, zinc) from low and high permeability soils; and
6. rapid recovery of aqueous soluble organic compounds (e.g., acetic acid, acetone, hexachlorobenzene, phenol, etc.) from both low and high permeability soils.

Some of the attractive features of EKAR are that it:

1. may be used in areas where contaminated soils may not be excavated;
2. is applicable to soils with high through low hydraulic conductivity;
3. is effective in both vadose and saturated zones;
4. is effective for both organic and inorganic contaminants
5. has no depth limitations;
6. need not be operated continuously, and
7. has very low O&M costs.

Purification Methods of Ground Water from Iron and Manganese in the Aquifer and Usage Prospects of this Technology in the Water Supply

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The purification technology of ground waters from iron and manganese consists of the influence by air oxygen on ground waters directly in the aquifer.

Single-well and double-well installations of cyclic action and also multi-well installations of VYREDOX (Sweden) type of constant action are used for the purification of ground waters in an aquifer. Single-well and double-well installations are designed for periodic work of wells with an alternation of cycles of oxygen enriched water injection into the aquifer and clarified ground water pumping. Multi-well installations provide persistent water supply clarified of iron and manganese.

Economically, the usage of iron and manganese purification technology of ground waters within aquifers is preferable to traditional surface installations. The capital investments for building of purification installations in stratum is 3-5 times less, in comparison with traditional plants, and the operating costs do not exceed 15% of the expenses of standard surface plants. Besides, with the ecological problems caused by the utilization of the waste waters removed, this purification technology may achieve 15-20% more from the water supply value than the surface installations.

Using Hydrobionts as Bioidicators of Wastewaters and for Biological Restoration

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The modern technologies of biological purification of wastewater are directed at maximal reduction of its negative effect on natural ecosystems. Among various directions of utilization of heated waters of power objects, the most promising is the creation of biotechnological complexes. These complexes include technological lines for cultivation of microalgae such as chlorella and spirulina, food and fodder invertebrates, fishes, as well as other objects of aquaculture. Thus the association of power and biotechnological objects in a single system is mutually advantageous not only in economic aspect, but also from the viewpoint of nature protection. Creation of biotechnological complexes at power stations will allow not only utilization of low-grade heat for accelerated biological production, but also the use of hydrobionts as a system of bioindicators of wastewaters and for recovering their biological state.

The Institute of Hydrobiology of the Ukrainian National Academy of Sciences together with the scientific and engineering center "Potential - 4" developed a process based on the use of hydrobionts (microalgae, invertebrates, water plants) for after-clearing wastewater of the household and food enterprises. Incorporation of separate hydrobiological unit next to physicochemical and microbiological treatment makes the drains more clear, their biological properties approach those of natural waters. Received biomass of hydrobionts of various trophic levels is used for creation of technical and fodder preparations.

Bioremediation Field Demonstration of a Sludge Lagoon at a Polish Petroleum Refinery

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The U.S. Department of Energy and the Polish Institute for Ecology of Industrial Areas have been cooperating in field studies of environmental remediation since 1995. One of the major focuses of this program has been the demonstration of bioremediation techniques to cleanup the soil and sediment associated with a waste lagoon at an operating petroleum refinery in southern Poland. After a thorough characterization, treatability study, and risk assessment study a remediation system was designed that took advantage of local materials to minimize cost and maximize treatment efficiency. The innovative biopile design deployed a combination of passive and active aeration and injection of nutrients to increase biodegradation of the very acidic soil containing high concentrations of polynuclear aromatic hydrocarbons (PAH). Simultaneous lab studies using soil columns were used to optimize treatment techniques and verify field observations under more controlled conditions. This full-scale demonstration showed that with minimal cost the total mass of petroleum hydrocarbons could be reduced by more than 75% in only 9 months. During this time the most toxic compounds were reduced to levels acceptable for multi-use resource activities. Though a variety of biodegradation monitoring methods were used in situ respiration and dehydrogenase activity were found to be best correlated with rates of biodegradation in the biopile. In addition, it was found that passive aeration alone could reach the same end point as the active aeration, it just took longer. The cost savings from passive aeration may give it a significant advantage over active aeration when clean-up time is not a primary consideration.

Critical Biogeochemical Parameters Used for In Situ Bioremediation of Solvents in Fractured Rock

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Two full-scale demonstrations of in situ bioremediation via bio-sparging/bioventing illustrate the critical biogeochemical parametersfor in situ bioremediation of solvents in fractured rock aquifers. Both sites were in Virginia, but differed significantly in contaminant composition. One site was dominated by non-chlorinated solvents at high concentrations, while the other site had only chlorinated alkenes. Both sites showed rapid responses to sparging and eventually required various other nutrient supplements

to maintain high biodegradation rates of the chlorinated solvents. The actual field data will be used in this talk to compare and contrast critical parameters for sediment and fractured rock. Fractured rock environments present some unusual obstacles to subsurface biostimulation. It was found that careful control of injection pressure, increased screen lengths, and increasing the number injection points can provide reasonable solutions. Helium tracer tests, respiration tests, pressure analysis over different injection conditions and measurements of microbial activity parameters, electron donors, electron receptors and daughter products help provide monitoring for controlling the bioremediation process in fractured rock.

Enhanced Bioremediation of Trichloroethene Contaminated Groundwater by a Biobarrier System

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Ground water at many existing and former industrial sites and disposal areas is contaminated by halogenated organic compounds that were released into the environment. The chlorinated solvent, trichloroethene (TCE), is one of the most ubiquitous of these compounds. One cost-effective approach for the remediation of the chlorinated-solvent contaminated aquifers is the installation of permeable reactive zones or barriers within aquifers. The objective of this proposed study was to assess the potential of using a barrier system to clean up aquifers contaminated by TCE. This system includes a peat (used as the primary substrates) barrier to enhance the aerobic cometabolism of TCE and its degradation by-products. Microcosm experiments were conducted to assess the feasibility of using peat to activate the TCE degradation processes. Results indicate that TCE was biodegraded to low levels using peat as the primary substrate. A laboratory column experiment was performed to evaluate the feasibility of using the biobarrier system to remediate TCE contaminated groundwater. This laboratory-scale system contained a series of continuous-flow glass columns: a first soil column, a peat column, and a second soil column. Approximately 1 mg/L of TCE was injected into the system with a flow rate of 500 mL/d. After a two-month operation, TCE concentration dropped to below 20 £gg/L after the biodegradation processes in the biobarrier system. Results of this study will aid in designing a system for field application. The proposed peat barrier treatment scheme would be expected to provide a more cost-effective alternative to remediate chlorinated-solvent contaminated aquifers.

Natural Attenuation of Chlorinated Solvents in Ground Water at the Naval Undersea Weapons Center Division Keyport, Washington

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U.S. Geological Survey

Ground-water flow constraints and natural attenuation processes are pre-venting chlorinated solvents from migrating to domestic wells near the Naval Undersea Weapons Center Division Keyport, Washington. Trichloroethene (TCE) leaching from a former 9-acre landfill is the primary chlorinated-solvent source of concern.

The hypothesis that chlorinated solvents will not be transported to existing or future domestic wells was tested using a weight of evidence approach. The evidence examined included inferred and modeled ground-water flow directions and rates, the spatial distribution of oxidation-reduction processes in ground-water, the spatial distribution of TCE and its degradation daughter products in ground water, and laboratory microcosm results regarding biodegradation of daughter products. Observed water levels and numerical flow-modeling showed that ground-water from beneath the landfill does not flow to any existing or to any likely future domestic wells. Ground-water age-dating showed that flow rates away from the landfill are relatively slow, allowing biodegradation processes time to work. The observed progression of methanogenic and sulfate-reducing conditions in ground-water beneath the landfill, followed by iron-reducing and aerobic conditions down-gradient, is conducive to complete degradation of TCE and its daughter products cis-1, 2-dichloroethene (DCE) and vinyl chloride. The observed distribution of TCE, DCE, and vinyl chloride in ground water supports that such degradation is occurring. Laboratory microcosms using aquifer sediments from the site confirmed that both DCE and vinyl chloride can be directly oxidized to carbon dioxide under conditions found immediately down-gradient of the landfill. A ground-water flow and contaminant transport model was used to integrate the evidence and show that the existing plume is likely at steady-state.

Overall, the likelihood that chlorinated solvents will reach domestic wells is very slight. Thus, a relatively passive source reduction strategy (phytoremediation) was selected as a remediation strategy for the site over more intrusive and costly alternatives.

Assessment and Monitoring of Natural Attenuation of Petroleum Hydrocarbons and Chlorinated Solvents

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Characterization efforts at the U.S. Navy installation in the San Francisco Bay Area discovered groundwater plumes consisting of petroleum hydro-carbons and chlorinated ethenes. Groundwater monitoring at the installation has been conducted since early 90s. In 1998, a study has commenced to evaluate whether the natural attenuation processes (primarily in the form of intrinsic biodegradation) are active within the contaminant plumes and are limiting contaminant migration.

The assessment of the natural attenuation efficiency at several sites included: 1) analysis of historical groundwater data on petroleum and chlorinated hydrocarbons and 2) collection of two rounds of groundwater samples for geochemical indicator parameters and dissolved gases. Groundwater samples were analyzed for total petroleum hydrocarbons and volatile organic compounds including tetrachloroethylene (PCE), trichloroethylene (TCE), isomers of dichloroethylene, and vinyl chloride. Measured indicator parameters included dissolved oxygen (DO), nitrate, manganese (11), iron (11), sulfate, sulfide, methane, ethane, ethene, redox potential, alkalinity, and pH.

_____ contaminated by petroleum hydrocarbons, the indicator parameter data clearly showed that intrinsic biodegradation actively controls the source areas. Concentrations of petroleum hydrocarbons decreased historically with time at the "source" wells. Current measurements at these wells showed (1) depleted DO, nitrate, and sulfate; (2) increased levels of ferrous iron; (3) high concentrations of sulfide and methane; and (4) elevated alkalinity. Field data from two solvent-contaminated sites showed that natural attenuation is effective in limiting plume migration at one site, while redox conditions at the second site result in the persistence of PCE and TCE downgradient from the source and reductive dechlorination is less efficient. Field and modeling studies are being continued to further evaluate whether monitored natural attenuation may be appropriate remedial altenative for the sites.

Microbial Diversity in Lake Baikal Water and Sediment Samples as Determined by an Extensive Isolation Program

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Lake Baikal in Russia, the world's oldest and deepest continental lake lies in south central Siberia. It contains one-fifth of all the fresh water on Earth. Lake Baikal was formed when water from a number of rivers in the region flowed into crevasses that appeared in the Earth's crust over 30 million years ago. Sampling this pristine ecological niche provides a unique opportunity in the search for microorganisms.

In an ongoing collaborative project, over 200 strains were isolated from Lake Baikal water samples collected at depths down to 90 m, from hot springs surrounding the lake, and from sediment core samples obtained during the 1998 drilling of the international Baikal Drilling Project (BDP). The extensive isolation program used a selection of microbe-specific low-nutrient content media and incubation conditions. The isolated strains were preliminarily identified based on fatty acid methyl ester (FAME) analysis data. Some 20% of the strains seem to be novel microorganisms. Strains were preserved immediately after isolation and are maintained at –86°C. Further screening will investigate the unique capabilities and/or novel biologically active compound production of the isolates.

Microbiological Investigation of Deep Subsurface Sediment Samples in the Framework of the Baikal Drilling Project

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Cores of Lake Baikal sub-bottom sediments were aseptically sampled at several drilling sites (Academician and Central Ridges, Posol'skaj Bank, Buguldeika Saddle). Our isolation efforts focused on aerobic, heterotrophic bacteria in these samples. Three temperature regimes (4°C, 30°C, and 60°C) were chosen for isolation of psychrophilic (or facultative psychrophilic), mesophilic, and thermophilic bacteria, correspondingly. Substantial numbers of viable bacteria (10^5-10^7 cells/g) were detected. However, no thermophilic microorganisms were isolated.

To increase the number of culturable soil bacteria, we applied our pioneering alternating magnetic field separation and concentration technique, which differentiate between the physical properties of the matrix and the microorganisms. It increased the number of culturable soil bacteria by up to two orders of magnitude.

Analysis of morphological and physiological traits indicates that there is a dominant species, nevertheless, the deep subsurface microbiota appeared to be quite diverse. Diversity did not decrease with depth. We also characterized some samples without culturing the microorganisms.

Some 40 bacterial isolates were analyzed by a non-radioactive modification of the genomic finger-printing method based on the application of biotin-labeled single-strained M13 bacteriophage DNA as a universal probe. We used a traditional set of restriction endonucleases. The analyzed bacteria were isolated from sub-bottom sediments obtained during the Baikal Drilling Project in 1998. The age of the deepest sediments is estimated to be more than 10 million years.

The comparison of the microbiota in different geological formations is in progress.

This work was supported through a U.S. Department of Energy (Grant subcontract 6480540) and, in part, by RFFI (Grant 97-04-96171).

Landfilling Practices in the Mideast: Putrescibles and Leachate Recirculation Equal Gas and Leachate Management Opportunities

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Dr. Shuhua Cui
Golder Associates (UK) Ltd., Maidenhead, England Presenter

The municipal solid waste received at landfills in the Mideast is generally quite different from what we typically find in North America. Although the waste composition in question is now gradually approaching that reported in the United States in terms of paper and overall biodegradable volatiles, there is still a much larger amount of putrescibles such as food waste and fruits being landfilled in countries like Israel and Lebanon. A significant percentage of wet, easily biodegradable organics (generally 54 percent or more by wet-weight as compared to 8 or 10 percent in the United States) is present in the municipal waste received at such landfill sites. This high percentage of wet waste (received at moisture contents in excess of saturation capacity) has a telling impact on landfill gas and leachate production. This paper addresses the effect of excess moisture (at times more than 30 percent above absorptive capacity) and the large volume of highly biodegradable organics on the rapidity of gas and leachate production within these landfills. Also addressed, is the chemical production of additional moisture within the fill due to the decomposition of these putrescibles and the impact of both baling and area-fill on the management of the moisture released through decomposition and placement of these wastes. Various first-order and multi-phase kinetic gas and leachate

generation models are presented which demonstrate the impact of increased biodegradability and moisture content on the life cycle of the landfill. These models provide useful design criteria which may be applied to leachate management (recirculation and on site treatment) and subsequent enhanced landfill gas production and utilization. Biographical Sketch Mr. William Clister, a Professional Geologist (with 30 years of landfill gas, soil vapor extraction and site remediation experience) provides technical support for various landfill site related assessments and corrective actions in the United States, Canada, the Mideast and Southeast Asia. His experience includes assessment of the groundwater impact potential of landfill gas and volatile organics migration at municipal solid waste landfills and development of numerous gas management programs. Dr. Shuhua Cui obtained her Ph.D. in Environmental Engineering at the University of Newcastle-upon-Tyne, in England and has over 15 years of wastewater treatment experience. She has worked in all aspects of process design including landfill leachate treatment. Her most recent leachate treatment designs are being applied to landfills in the UK, Lebanon, Israel and Hong Kong. Dr. Cui has produced various technical presentations for landfill leachate management and soil remediation projects.

Geochemistry/Hydrochemistry

Equilibrium - Nonequilibrium State of the Water - Rock System and its Self-Organization

S.L. Shvartsev

During many years we studied the water rock equilibrium. At first stage our research concerned fresh and salt waters on the zone of hypergenesis in different regions of the world. Then we started to solve this problem with respect to salt waters of sedimentary petroleum bearing basins of the West Siberian platform. Recently we have also studied the equilibrium of strong brines of the chloride-calcium type of the Siberian platform with water containing rocks.

The results of the study of the saturation states of various underground waters with different minerals show that under natural conditions the water-rock system is in the equilibrium-nonequilibrium state throughout the Earth's crust. Water is always in nonequilibrium with some minerals of magmatic or metamorphic genesis, but simultaneously it is in equilibrium with a set of secondary mineral phases. Thus water continually dissolves some endogenic minerals and secondary products forms. There are neither thermodynamic nor kinetic restrictions to this kind of development of the system under consideration. A secondary mineral complex of any composition being in equilibrium with water forms over the whole period of the water-rock interaction, and not only when the local equilibrium takes place. This process is of a continuous, regional, and nonlinear character, which is a distinguishing feature of synergetic self-organization systems.

For example saturated waters with respect to calcite remain at any mineralization undersaturated with respect to anorthite. Therefore, anorthite can dissolve in any type of water because calcite serves as a chemical barrier in achieving the water-anorthite equilibrium.

Consequently, the water-rock system in this case is characterized by the equilibrium-nonequilibrium state, which supplies a continuous anorthite dissolution and calcite formation, with calcium passing from the former mineral into the latter.

An equilibrium-nonequilibrium state of the rock-water system deter-mines its ambiguity promoting a continuous interaction due to the tendency to equilibrium, nowhere and never fully achieved for a number of reasons under the geological conditions. Nonequilibrium of the system drives it to a continuous inner self-development, the formation of new structural-spatial formations (secondary minerals and geochemical water types), and the origin of synergy self-organization phenomena in the area far from equilibrium.

Therefore, while interacting, the two phases (water and rock) give the origin to a new (secondary) formation, which is an explicit indication of the system's complication and development. The originating secondary mineral phase forms new structural elements thus giving to the developing system new properties not intrinsic to it before. At the same time, the composition of water solution itself changes forming a new geochemical medium based on the chemical components obtained from the rock and water itself. This new geochemical medium influences the nature of the secondary mineral phase that finally modifies its own composition.

It is important that in this case the water-rock system evolution leads to a selective concentration of chemical elements in water solution, which in turn determines the directed change in water structure at the same temperature. Therefore, changes in water structure encode information serving a signal for ions of the solution to change their behavior.

Having analyzed the available factors, we put forward the statement that the main code information directing the evolutionary development of water-rock system is laid down into the structural features of water solution. This is due to capability of this water solution to multiple structural changes under a slight influence of chemical ions, temperature, and pressure, electric and magnetic fields, etc. The structural changes of water solution serve the basis for providing information, which directs the action of the mechanism of selection of the ion interaction forms in the solution with the subsequent formation of particles and their "pushing out" from the medium of origin. As seen, in terms of modern synergy, the geological water-rock system possesses all the important indicators of self-organizing matter. They are: a contradictory nonequilibrium-equilibrium state retaining through-out the entire geological history; non-linearity of leading processes; capacity for spatial-temporary development; the regulation mechanism for interactions with the environment; selective choice of composition of the forming secondary mineral and water phases; capacity for their reproduction; geological self-regulation mechanism; evolution autonomy independent of the initial parameters that determined its origin; availability of structural formations able to assimilate, accumulate, evaluate, and pass information, including the canal of return communication.

Thermodynamic Properties of Sedimentary Minerals and Aqueous Species in the DiaNIK-99-Win Database for Applications to Hydrogeochemistry

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Completeness and quality of thermodynamic data substantially influences reliability of the conclusions about the main forms of the chemical elements existence in aqueous solutions and bottom sediments. These data are needed to describe various processes controlling the contaminants migration in aqueous ecosystems.

Computer database *"DiaNIK-99-win"* is an interactive research information system of chemical thermodynamic data for individual inorganic substances (including minerals) and aqueous systems. *"DiaNIK"* has been developed at Vernadsky Institute based on systematic collection (during 35 years) of all available published results of experimental investigations. Updating the database is performed annually.

A substantial portion of the thermodynamic values collected by the *"DiaNIK"* experts relates to the sedimentary minerals and aqueous species including complexes. The structure of thermodynamic database *"DiaNIK"* is based on the principles, developed by CODATA International Group on Geothermodynamic Data for working up thermodynamic information. The accepted structure allows performance of the following consistency procedure: (1) for the individual substance, aqueous solutions and the individual chemical reaction as well (*"local consistency"*); (2) for the chemical systems, containing a set of substances (including aqueous species) and reactions (*"global consistency"*).

The ordering of the binary aqueous solutions and chemical reactions used in the *DiaNIK* database is based: (1) on the thermochemical standard consequence; (2) on the number of chemical elements in the system.

There are two main parts in the expert version of the database: (1) brief summarizing information on all available published experimental studies (property of interest, a method of the investigation, temperature/pressure/ concentration interval, uncertainty of the data, ionic strength, supporting electrolyte and a reference); (2) part of the primary data sets considered for the best value selection in the *DiaNIK* user version (mainly according to a professional interest of the experts). A number typical examples of the use of the *"DiaNIK-99-win"* thermodynamic data for the computer simulation of the toxic chemical elements (Pb, u, Zn, Cd, Hg) behavior in aqueous system are presented.

The Principles for Selection and Synthesis of Optimal Predictive Groundwater Quality Models for Exploration and Exploitation of Groundwater Fields

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The paper considers the ways and optimal conditions for application of geochemical models (thermodynamic and kinetic) in solving the problems of drinking groundwater quality and control of the latter. The classification of geochemical processes is made, which serves as the basis for selection of predictive models for homogenous and heterogenous hydrogeochemical systems. The classification is based on the ratio of the number of phases a system has to the rates of geochemical processes that proceed in it. The development status of predictive geomigration, thermodynamic and kinetic models, the level of their provision with information and computer software are shown. Analysis of the problem made it possible to determine the ways of synthesis of transport, thermodynamic and kinetic models in predictive model complexes. The optimal approach is the separate implementation of transport, thermodynamic and kinetic models.

The Assessment of Ionic Transportation into Seas

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The authors reveal that the regional and global regularities in the formation and distribution of the groundwater runoff into seas and oceans provide a pioneering way of estimating the contribution of certain components of solid groundwater discharge to hydrochemical regime of coastal zones. For this purpose, a regional assessment of transportation of major elements and nutrients was performed for selected references of different continents. Data on the groundwater chemical composition within the coastal zone were obtained using the following approaches: analysis and generalization of the factual data of case studies of the ground water chemical composition at separate localities within coastal areas; statistical estimation of the major elements content of groundwater using data on the groundwater TDS and pH in the coastal zone, as well as data on the composition of water-bearing rocks; application of data on the composition of river waters during the stable low--water period when the groundwater is the main source of the base flow for minor and middle rivers.

These approaches were applied for estimating the groundwater transportation of major elements within the coastal zones of Africa, Australia, and South America and are to be performed on other continents. The data obtained provides a means for comparing the selected areas of the coastal zone. It reveals the specific features of the ground water transportation of ions under different natural conditions, assesses the contribution of groundwater transportation to the salt and water regime of selected areas, and establishes cause-effect relations between the groundwater transportation and the natural and anthropogenic processes on land and sea.

This work was supported by the Russian Foundation for Basic Research (project no. 05-64107).

Basin Landscape-Geochemical Mineralization Calculation Method

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MODEL FORMULATION

Model based working formula. Non-irrigated basin with initial conditions: constant discharges and initial mineralization of water, natural steady salination of soil and under-surface layers of the whole area, at the final hydro-station we will see the same discharges and mineralization that are at the initial hydro-station. In this case the quantity and contents of water salt (passed by the initial (Sin) and final (Sfin) stations will be equal.

Another model where the part of the basin is irrigated under the same natural conditions shows that geochemical discharge carried by the river stream through the final station will contain the salts: 1) passed by the initial hydrostation and 2) washed out of the soil and minerals of the irrigated area.

In this case salination balance of the model basin will be shown in the equation

$$S_{fin} = S_{int} + S_{wsh} \quad (1)$$

where S fin - amount of salts passing by the final station with river water; S int - amount of salts in river water at the initial station; S wsh - amount of salts washed out from soil and minerals of the irrigated part of the basin in a considered period of time (kg, tons, mln.tons, etc.) In the equation (1) S wsh can be substituted by S o * F ef, where S o - amount of salts washed out from a surface unit, F ef - all washed out surface. Then the equation (1) will be:

$$S_{fin} = S_{int} + S_o * F_{ef} \quad (2)$$

The amount of salts passed by the initial and final stations per time unit is:

$$Q_{fin} * M_{fin} = Q_{int} * M_{int} + S_o F_{ef} \quad (3)$$

where Q fin and Q int - water discharges at the initial and final stations (liters/seconds or cubical meters per second); M fin and M int - mineralization of water at the initial and final stations (grams/liter). In case the model works there won't be any loss of discharge water within the basin, so water consumption at the initial station will be equal to the water consumption at the final station (Q fin = Q int)/ Let us divide all members of the equation (3) by Q int:

$$Q_{fin}/Q_{int} * M_{fin} = Q_{int}/Q_{int} * M_{int} + S_o/Q_{int} * F_{ef} \quad (4)$$

Of course, the author realizes that in reality this balance is often violated by economic activities.
After some elimination the equation (4) looks like:

$$M_{fin} = M_{int} + S_o/Q_{int} * F_{ef} \quad (5)$$

Characterizations of Geochemical Changes in a Vadose Zone Recharge System, Scottsdale, Arizona

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HydroSystems, Inc.

Christine Close
Dames & Moore

Floyd Marsh
City of Scottsdale

The City of Scottsdale is developing a state of the art artificial groundwater recharge facility called the Water Campus in north Scottsdale. This recharge facility consists of two types of large diameter vadose zone wells, either cased or uncased. The vadose zone recharge well method at the Water Campus has been developed over the past four years and several types of vadose zone recharge wells have been constructed and tested at the facility during the pilot phase. As part of the pilot recharge well testing, the water quality of the source water has been sampled and evaluated. The project is now entering full scale operation and the geochemical reactions of the source water and soils occurring in the unsaturated zone will be of paramount concern to the operation and maintenance of the vadose zone well field.

The water quality analyses have shown changes in the levels of arsenic, barium, fluoride, and iron during the pilot phase of the testing. The City of Scottsdale has collected water quality samples throughout the pilot phase testing however, limited analyses has been completed. This project will evaluate the geochemical changes based on the existing water quality data base developed during the pilot phase, and provide an analysis of the changes that may take place during the full scale operations. Results of this geochemical modeling could be used to assist the City of Scottsdale in the future operations of the recharge facility. Results of the geochemical modeling could also provide a foundation for other similar projects to define operations and maintenance problems.

The Hydrogeochemistry of Groundwater in Fractured Bedrock Aquifer in the Lublin Cretaceous Region, Eastern Poland - Natural Chemical Background Versus Contaminant-Induced Changes

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Water of HCO3 Ca type occur in fractured Cretaceous bedrock, locally covered by thin, ranging typically from 2 to 10 m, Quaternary deposits. Values of TDS range from 500 to 700 mg/L, and waters are slightly alkaline with a typical pH of 7.1 to 7.4, and relatively high hardness values. Hydraulic conductivity of the aquifer is about 1 m/day up to 10 m/day in more fractured parts. The regional aquifer is unconfined and water table typically located at a depth of 5 to 15 m. Thus, the regional aquifer is very susceptible for contamination. Because of the agricultural character of the region with only two industrial towns, non-point agricultural contamination is of the greatest concern. A long-term monitoring program at hydrochemistry of this area allowed to compare results for a period of thirty years. Elevated concentrations of chlorides, sulfates, nitrates and nitrites, as well as local values of TDS exceeding 1,000 mg/L indicated contaminated areas. However, some of the elevated concentrations, for example strontium, have geogenic origin. Additional other contaminations were localized, including elevated concentrations of chromium caused by storage of chromite-magnezite blocks, and elevated concentrations of iron and ammonium indicate contamination by local waste-disposal sites.

Characteristics of the Vadose Zone Hydrochemistry with Respect to Copper and Zinc Ions

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Anomalous concentrations of Copper and Zinc typically suggest either proximity to ores of Cu and Zn or contamination of subsurface water from other sources. Copper and Zinc were determined in atmospheric precipitation to assess contribution of this long distance contamination in the infiltrating water into the vadose zone. Chemical reactions and physical processes were monitored in the subsurface, from the ground surface, throughout the entire vadose zone, and up to water table. Two areas of study were selected in Poland very carefully to avoid local, unknown, short term contaminations. One area of study - the Bialystok Highland, is located in North-Eastern Poland, the other study area is located in the Kampinas National Park in central Poland. Changes of types of ions in aqueous solutions and in solid phases of Copper and Zinc are monitored in unconsolidated Quaternary deposits. Both areas are characterized by a different lithology, grain size distribution, content of clay minerals, content of organic matter, and mineral composition. Sediments from the Bialystok profile contain more clay minerals and organic substances, with a substantial amount of CaCO3 acting as a buffer, and slightly alkaline of water in the vadose zone. The Kampinos profile contains less organic material, is predominantly sandy and silty and has slightly acidic character of water in the vadose zone. In both areas of study, sediment which occurs in the vadose zone were examined with respect to possible sources of Copper and Zinc. Although ions Zn+2 and Cu+2 are the most common in both study areas, other ionic species significantly differ between the two profiles. The Kampinos profile is characterized by a very small amount

of other ionic forms, while contribution of CuCO3, Cu(OH)2, ZnCO3, and ZnHCO3+ is substantial in the Bialystok area. Presence of different ionic forms and solid phases are discussed in reference to calculated sorption capacities of sediments present in both profiles.

Environmental and Hydrogeochemical Problems of Transbaikalia

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Unfavorable environmental and hydrogeochemical situations of natural and anthropogenic character are considered in the report.

Among unfavorable natural situations are a widespread occurrence of substandard drinking waters and their depletion in some macro- and microelements. In the zone of excessive moistening, groundwater features the excess of the standards of Fe, Mn, and sometimes Si. The concentrations of F, J, Se, and some others fail to reach the standard. In the arid zone, the content of F often exceeds the standard. Hydrogeochemical anomalies of fluorine, caused by its high clarke in host rocks, have been determined in all landscape-climatic zones. Fluorine concentrations in such anomalies reach 2-4 mg/l at the water mineralization 30-50 of mg/l. Sites with a high content of As (up to 2 mg/l) and other heavy metals in waters are known.

In the context of a new phosphate-manganese hypothesis, hydrogeochemical characteristics of the area of Urov disease (a heavy illness of the osseous-articular system of people and animals widespread also in northern China and Korea) are analyzed.

In a series of anthropogenous changes, contamination of surface and subsurface waters as a result of wastewater discharge into river network and municipal wastes entering into groundwater is considered.

A special case is a problem of drainage of ore deposits, the development of which in Transbaikalia has been conducted for about 3 centuries. There are two types of physical and chemical situations in surface and subsurface waters caused mainly by different composition of host rocks. During localization of sulfide-bearing ores, acid waters (pH < 4) are formed in aluminosilicate rocks with concentrations of tens and hundreds mg/l of ore- and rock-forming elements (Fe, Cu, Zn, Pb, Ni, Al, F, and others). The behavior of Al and F forming stable alumofluoride complexes is specific in such waters. In the case of carbonate host rocks, waters have near-neutral reaction and 1-2 orders lower concentrations of metals.

Numerous ore deposits of Transbaikalia have a considerable negative influence on water ecosystems since the purification of the drainage is not done. An example of Au deposit is used to show that the application of lime method being much used, including US, does not guarantee sufficient purification of acid drain waters from metals and fluorine.

Hydrochemical and Isotopic Imprints of Hydrodynamic Environments of Fissure Waters in Crystalline Rocks

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The increasing interest to the studies in sphere of vertical and horizontal migration of fluid in crystalline rocks is connected with the process of disposing of nuclear wastes and construction of engineering buildings. Such studies have to give the possibility to create the models of many hydrogeodynamic and hydrogeochemical processes. The geochemical theories and models of water's role in forming of crystalline rocks are less worked out, but such models are to be taken into account during creation of industrial units. Hydrochemical and isotopic data have seldom been used in hydraulic modelling of rock masses. Our studies in Baikal Rift Zone (Russia) and Fenvy Rift (China), works of other authors show, that these indicators are long-term for modelling of fissure waters movement. The complex analyses of information was carried out on the example of construction of Severo-Muysky (North-Muisk) tunnel 15 km long with the use of isotopes of tritium, uranium, strontium and other elements. The materials were also analysed with the use of indices of geostatic condition, parameters of fissureness of rocks, volumes of water flows, geochemical data. More than 25 parameters were used for the statistic processing. The result of calculations gave possibility to distinguish the new type of fissure waters, which circulate in the system of bloc structures, which form crystalline rock masses. The process of movement and recharge of waters goes within the same bloc. With the help of methods of pattern recognition were determined the boundaries of blocs, appraised the difference in the forming of types of fissure waters, and also were calculated their infiltration rates and balance. On the example of deposit of fissure waters Siping'an in the Shanxi Province such indicators as isotopes of deiterium and oxygen-18; hydrochemical indices - fluorine, strontium, chlorine, lithium and others give the opportunity to form three-zone vertical hydraulic model, which doesn't except the contamination of termal waters by agricultural fertilizers.

Technogenic Variations of Composition of Mineral Waters During Overflow from Bore Holes

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According to data of long-term observations of natural overflow of mineral waters at boreholes, employed by sanatoria and health-resorts at the territory of the Baikal Rift Zone, the following was stated:

(1) under conditions of water discharge, provoked by drilling, a substantial metamorphization of water composition at the oxygen barrier takes place in the ascending flow of deep fluids, diluted by infiltration waters;
(2) intensive metamorphization of Fe and Mn occurs in cold pressure waters in the areas of sedimentary deposits causing the precipitation of Fe and Mn minerals around the boreholes. In the shore zone of Lake Baikal the mechanical drift of precipitated material into the Lake's water occurs. This process is possibly responsible for the formation of the iron-manganese concretions at the bottom of Baikal.
(3) the drilling process causes the destruction of accumulations of gaseous hydrates within the Baikal water area. This leads to the release of methane and other heavy

hydrocarbons, which get into the thermae or to the points of the subaqual discharge of methane gases.

(4) deep boreholes (up to I km) in the faults of the basement of the Tunka depression have revealed carbonaceous hydrothermae overlain by a series of Neogenic sediments. Waters have shown high relative concentrations of mantle helium (^{3}He) and the ^{4}He/^{4}He-ratios reaching the values of $n \times 10^{-5}$. However, the monitoring observations (1986-1998) have shown that this ratio is gradually decreasing due to an expenditure of accumulated gas masses. A quantitative theory of this process is suggested.

(5) in the methane thermsae revealed in lower layers of the sedimental mantle of the Tunka depression, the metamorphization of carbon dioxide to methane occurs, accompanied by a regular decrease of the ^{3}He/^{4}He-ratio.

(6) a theory based on differential equations in partial derivatives and Arrhenius law is developed which allows to explain balances of radiogenic gases lost by wall rocks and acquired by groundwaters and to introduce a time scale into models of hydrogeologic processes.

(7) the discharge of carbonated and nitrogen thermal waters is accompanied by the intensive formation of a solid phase in the form of travertines, sulphate minerals and geyserites.

The Heavy Metals Content in the Natural Water Surrounding the Armenian Atomic Electric Power Station

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The peculiarities of the heavy metals (Fe,Mn,Zn,Co,Cr,Ni,Ti,Pb,V,Ag,Sn, Cu) migration and accumulation in the water surrounding the Armenian Atomic Electric Power Station (the subsoil water, the lake Akna, the pump station of AEPS-the river Metsamor) and in the water flowing out from the AEPS were studied by us in 1996-1998. It was shown that the heavy metals content was higher in the water flowing out from the AEPS(3,1mg/l) and lower in the subsoil water (0,8mg/l). The heavy metals content in the natural water was the following: Fe>Zn>Ti>V>Mn>Ni>Cu>Pb>Cr>Mo>Co>Sn>Ag. In the water flowing into and out of the AEPS the content of Cu,Ti,Ni,Zn in the station increased by 1,6 times and the content of Fe, was increased by 1,4 times. The increase of the concentration of Cr,Mo,Ag was insignificant. The heavy metals content in the natural water surrounding the Armenian AEPS is in permissible limits.

Basics of Medical Geology

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Health level of a population mostly depends on conditions of the environment. That is reason why it is not so strange that specific discipline of medicine, in other words, of geography - that is, medical geography, has started to develop very early. Based on several natural and social sciences, by the discipline, generalized information on some territory and appropriate diseases was synthesized at wider geographic basis. However, it was not dealing with essential factors - carriers of a certain disease. The mentioned gap will be mostly filled by medical geology, a discipline analyzing relationship between

geological factors and population health (occurrence of some diseases within an interesting geological unit). Possibilities of geology in that field have not been considered so much. From that point of view, by successful discoloring of carriers of some disease, diagnostics of the disease would be improved, as well as ways for efficient treatment found.

In the paper, geological risk factors, but also negative and positive influence of geological environment onto the human health, as a subject, tasks and methods of medical geology are presented. Particular attention was directed to medico-geological evaluation of the environment and measures for conservation the population health.

Mineral Waters of Greece - Key to Health and Advanced Cultures?

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Searching for hydrogeologic investigations in Greece (Athens, Metro-tunnel S. Akropolis) and by visiting cultural sites of antike Greek artists and sportsmen some comparisons obviously were evident with the local aquifer-well drinking-water chemistry (espec. Magnesium and Potassium content) of other main cultural sites like f.e. (alphab.): Babylon (Iraq), Byzanz (Turkey), Gizeh (Egypt), Jerusalem (Israel), Petra (Jordan) or Rome (Italy) concerning the paleogeografic genesis of the groundwater bearing sediments. From all these the former people get their drinking water from local wells dug in marine evaporitic derived mineralized sediments with high content of MgSO4-mineralization, i.e. solution by similar sedimentation cyclus and thus aquifer typus. Several sites named Magnesia are well-known SE Larissa and twice near Izmir (Smyrna, Manisia, Ephesos, Bodrum = Halikarnassos).

By drinking that high concentrated magnesium complex, medical reactions derive some proper oxigen-consumption for the human blood causing a better supply of brain, heart, nerves and muscles, hence improving the intelligence and health of human beings. Simultaneously the Sulfate consumption causes a better digestion and metabolism. Although these effects and additionally Fluoride, Iodide, Lithium, Magnesium, Potassium, Strontium causes the reaction: "mens sana in corpore sano ....." and might be the reason, that these former antike people were able to create their famous cultural development, quod erit demonstrandum by further interdisciplinaric geomedical-hydrogeologic investigations.

This - in modern hygienic sense bad because of urban contamination and sometimes too much Epsom salts containing - shallow groundwater (bitter mineral water), which was used in former times because of the lack of remote supplying systems causes high motivation and probably geogene originating intelligence. Austrian mineral waters too, like the spa (salus per aquam) Bad Radkersburg named "Longlife" (nomen est omen?) or the "Purgina" are enriched with Mg. But too much causes severe renal failure by Hypermagnesemia, whereas a moderate (< 29 ppm Mg, for therapeutic application 67 - 134 ppm/day) consumption by drinking water improves statistically brain performance,

concentration, stress tolerance and decreases blood pressure, myocardial infarct risks, neuromuscular hyperexcitability, asthmatics, cerebrovascular and total mortality.

Further on it is interesting that such salts were used as cathartic drugs during Renaissance times in Italy, as one might assume causing the origin of holy sites, like Assisi, Loreto, Lourdes, Mariazell, but also Canterbury, Glastonbury, Stonehenge, Tschenstochau, Salt Lake City (Mormones) or the river Ganges. Additionally improving also artistically abilities and faculties as known from sea coastal regions f.e. in the Netherlands (Rembrandt, Rubens etc) and the Toscana (Leonardo da Vinci, Michelangelo etc) would be imaginable by drinking that waters with more than 200 ppm Mg. Maybe that the colossus of Rhodos has been built by euphoria caused by to much intake from mineral water springs.

By the fact of actual existence of the local aquifers, already now available for sampling, the scientific argumentation by hydrogeochemistry in-situ-analysis of local domestic wells should be improved and manifest that hypothesis, hoping that GeoMedicine help to prevent from drugs and conduct to global social and economic progress.

"hydor men ariston"
"water is the best"
(quotation after PINDAR)

Having read at a well for water drinking cures on the island Kos (birthplace of HIPPOKRATES) dedicated to HYGIEIA - the Greek goddess for health.

Water Resource Management

Ground Water Resources and Their Use on the Eve of the XXI Century

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In the last decades, great attention has been paid to assessing groundwater resources as important and reliable sources for supplying the population with ecologically pure fresh water, in many countries of the World.

The paper characterizes the present state and perspectives of fresh groundwater resources use and shows the role of fresh groundwater in public water supply. It also discusses the interaction between groundwater and other environment components and the impact of human activities on the groundwater. A brief characterization of groundwater vulnerability to pollution encourages consideration of the problems of groundwater over-exploration and depletion. Tendencies of groundwater resources change for a distant perspective are analyzed. The role of groundwater discharge in the continental water balance is characterized. Furthermore, the paper reveals the part of UNESCO involved in organizing and carrying out large hydrogeological projects according to the International Hydrological Program and culminates in a brief formulation of the main goals of further investigations.

Bases of Sustainable Water Use National Policy in Russia

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The water sector of Russia is now in a system-wide crisis. The main reason is that the institutional-economic structure of the sector does not permit it to react adequately to the changing situation. Nor does it guarantee the generation of financial flows needed for its sustainable development.

To get over the crisis and for further perspective, the implementation of purposeful national water policy is necessary. It must be based on agreed upon concepts within a single document which touches on long-term goals, main tasks and implementation principles. This document will determine conceptual "game rules" for both authorities and water managing bodies, and enterprises, water users, and the population. Thus, it must be discussed with the participation of all interested parties (including water users), proclaimed and fixed as an official document. To implement these concepts, it is necessary to carry out the institutional-economic measures, develop legislation, and plan and realize technical measures.

At present the Ministry of Natural Resources of the Russian Federation has submitted a draft, developed by the authors, to be further discussed in details. We will cite the

theses of the second edition of the draft taking into account remarks and proposals received.

The goal of national water policy is to reach and maintain an economically optimum and environmentally safe water use level.

The national water policy must guarantee:

- the rights of present and future generations to use ecologically safe water resources;
- balanced requirements of social-economic development and possibilities of reproduction of ecologically safe water resources.

Achievement of these goals is referred to as sustainable water use. So sustainable water use is the strategic goal of the national policy in the sphere of conservation, efficient use, and reproduction of water resources. Later on, we will call this policy the "National Policy of Sustainable Water Use in the Russian Federation".

The main directions of implementation are.:

- creation of conditions for systematic supply of the population with an adequate amount of standard quality drinking water;
- protection of the public and the economy from harmful effects of floods, underflooding, water erosion, droughts, etc.;
- regulation of economic activity in order to achieve the balance between requirements of economic development and possibilities of reproduction of ecologically safer resources;
- step-by-step rehabilitation of the disturbed water ecosystems.

Basic principles of the sustainable water use national policy are:

7. Basin planning (at the Federal level) and territorial administration of the water related activity (at the level of RF constituents).
8. Gradual and persistent minimization of harmful impact on water bodies.
9. Step-by-step transition to a complete self-financing of water related activities.
10. Openness to broad public involvement in the process of decision making.

Environmental Problems of Use and Protection of Ground Water in Russia

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The environmental problems of use and protection of ground water are rather complicated and multi—aspect. They must be considered at least from the following three positions:

- protection of ground—water fields as unique natural formations against anthropogenic contamination and depletion;
- impact of ground-water extraction upon other components of the geoenvironment, surface water, economy and human health;
- social and economic significance of ground water.

The basic environmental problems of use ans protection of ground water are as follows:

- substantiation of actions on ground—water protection and remediation from an anthropogenic impact, basing on the results of estimated and predicted changes of water quality and safe yield in the course of groundwater exploitation;
- substantiation of actions on directed regulation of extracted water quality;

- estimation and prediction of geochemical consequences from anthropogenic ground—water contamination by oil products, phenols, pesticides and other contaminants in connection with the various transformations of the latter in the subsurface and active interaction with water—bearing rocks, low—permeable layers, microflora, accompanying often by formation of new toxicants, combustible gases, etc.;
- influence of ground—water extraction on development of karst and suffosion, earth's surface subsidence, land overdewatering and surface runoff, activization of other hazardous geological phenomena;
- working out methods to predict ground-water environmental state with use of a system of hydrodynamic, migration and geochemical models.

Solving of the above-listed problems must be based on: results of integrated geologo—hydrogeological, geochemical and other investigations of features of water—field occurrence and formation; up—date technologies for prediction of changes in regime, composition and properties of ground water caused by natural and anthropogenic factors. Here, looking for, understanding and substantiation of ways for solving the given environmental problems must be a top-priority task in prospecting and exploration of ground-water fields.

The Complex Hydrogeological and Medical-Ecological Approach to the Safe Use of Groundwater for Drinking Purpose

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At a time of burgeoning industrialization and urbanization, ground water essentially retains many advantages of clear drinking water sources. However, examples of adverse, particularly man-induced, impact on ground water quality, are being accumulated. The bank of medicoecological data currently taking shape indicates there obviously exists a direct cause-effect relationship between the sick rate of the population and the degrading water quality of the groundwater sources reserved for drinking purposes.

The new environmental situation calls for new approaches to the assessment of ground water quality and intensification of measures aimed at ground water protection and safe use.

The research problems involved are associated with the use of methods of hydrogeodynamics, hydrogeochemistry and geoecology oriented towards the receipt of target information in order to predict and assess the groundwater quality influence on human health. The full-scale development of the medicoecological studies calls for the elaboration of united methodology and unified methods of hygiene, ecological epidemiology and ecological toxicology. However, the most important in this context is the combination of medical investigations with comprehensive hydrochemical data. This problem can be solved only with the use of the interdisciplinary methodological approach put forward in this report, This problem can be solved only by joint efforts of experts in all the fields involved and on the basis of data exchange concerning the targets and progress of the investigation.

It is clear that the medicoecological studies are expected to provide a reliable basis for the selection of new safe subsurface water sources as well as for the improvement of ground water protection and water treatment technologies. At the same time, the lack of reliable data on the medicoecological situation related to the hydrogeological conditions

of water use as well as predictions of its evolution increases the probability of making incorrect decision.

Modeling of the Interrelation of the Intestinal Infectious Diseases and the Quality of Drinking Water

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The task of the study was to reveal the intestinal infections rate in the popu-lation in connection with the change of conditions of using water and the effect of chemical and bacteriologic pollution of water in the basin of the river Zarafshan.

The cases of intestinal infectious diseases had been studied in the regions experiencing the effect of industrial and communal sewage to confirm the obtained findings of the intestinal disease incidence in the population in connection with the chemical factor. The results of the study demonstrated the findings on the influence of the real chemical load on the incidence of intestinal infections among the population. To establish the inner complex interrelations between the dynamics of the intestinal diseases rate in the comparable groups of population, the quality of water in the established ranges of observation and the conditions of water-using, we had performed the multiple correlation and regression analysis. On the basis of mathematical modeling the interrelation of the intestinal infections rate and the quality of drinking water, the multifactor models were obtained.

The established regressive relations between the variables give the opportunity to use the equalities of multiple regression to forecast the synergic effect of the total pollution of water on the population health. Simultaneously these equalities may be used for quantitative evaluation of the specific characteristics of the dynamics of the population morbidity with intestinal infections under the conditions of changing sanitary and epidemiological situation in the arid zones. The obtained mathematical models represent adequately the interrelations of spreading infectious diseases in the population not only with the indices of bacteriologic but also and specific chemical pollution of water of the river Zarafshan.

A Framework of Quality Assurance Plans for the Environmental Surveillance in Florida

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The progress of Quality Assurance Plans or procedures (QAPs) in Florida over a period of the last ten years is interesting and substantial. The overview of these procedures is presented to discuss the Quality Assurance requirements that are necessary to carry out the field sampling methods and the laboratory analyses in Florida. The underlying principles of sound Quality Assurance Controls are discussed along with the components of the QAP framework. The advantages of QAPs are presented with their limitations. The approval process at the state and federal levels is also discussed. The

experience of the Florida Department of Agriculture and Consumer Services, an agency seeking the QAP approvals for pesticides monitoring and analyses, indicates that the awareness of Quality Assurance is high and is increasing at a rapid speed in Florida. This information is useful to state and federal regulators, researchers and the members of the Environmental surveillance teams.

Monitoring of Fresh Ground Waters - A Safe Base of Water Supply in the Republic of Uzbekistan in XXI Century

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The deterioration of surface and ground waters is caused by the natural and technogeneous conditions in the Republic of Uzbekistan. The close intercom-munication between underground and surface waters is supposed to deteriorate the fresh underground waters in a great number of deposits as the mineralization of surface waters is known to reach the limit or to be higher than that limited for drinking waters. Though this process is now invisible, but at any moment it may have a lot of unfavourable consequences.

Thus the assessment of the conditions of underground waters andalterations of them caused by the anthropogeneous and natural factorsare of great importance for taking timely measures for warning and preventing from the negative consequences of this process. This difficult problem has become the main aim of State monitoring of underground waters in our Republic (SMUW).

Functioning of SMUW and the achievement of the main purpose are proved to be a success if the underground water exhaustion and pollution processes on a read territory are explored and realized. For this purpose on different stages of exploration it is necessary to know:

- the structure of the exploitation ground water resources of a deposit;
- the degree of their pollution within a definite water catchment area. The higher degree of underground water pollution than it is admissible indicates the exhaustion and possible deterioration of discharged waters;
- the forecast indexes of their chemical composition.

In order to assess the danger of negative processes caused by the underground water exploitation the scheduled indexes of a definite water catchment area must be analysed and scientifically grounded.

The scheduled indexes are the following:

- mineralization forcast or the content of different components of discharged waters;
- initial and limited mineralization (chemical composition) of either surface flow being exploited or the adjacent ones.
- water table low in the well and in the centre of the depression cone of the exploited and adjacent water beds.

The scheduled indexes shall be corresponded to the specific observation posts.

The given approach is proved by high efficiency of SMUW in the processes of generation of the investigation data taken by means of monitoring. It allows us to take into account the alterations of the situation within a specific site being exploited in the underground water deposit.

The Analysis of Real Situation and Elaboration of Rational Use Strategy of Fresh Ground Water of Azerbaijan Republic

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Under existing conditions of Azerbaijan Republic water balance deficit the fresh ground water acquires special significance The main part of them relates to the Quaternary deposits of foothills and intermountain hollows.

The affirmation of ground water exploration reserves of Azerbaijan Republic deposits had been carried out by related organizations during the period of 1961—1981.

The analysis of real output situation showed that by the all deposits they were understated. The ground water exploitation reserves were approved only for economic and drinkable use, for the uniform annual output. In fact the main part of procured water are used for irrigation that reserves estimation method is distinguished. The absence of real data about wells had been drilled for different organizations and farms also makes difficulty to calculate ground water exploitation.

The real use of Azerbaijan Republic ground water allowed us to determine three main direction of hydrogeological investigations.

1. Ground water formation under the influence of natural and technologic factors.
2. The prognostic estimation of ground water resources quantitative and qualitative parameters change under the influence of technogenic factors.
3. The ground water protection in connection with their exploitation.

The Ground Water Formation of the Biggest Industrial Centers of Azerbaijan Republic under the Influence of Intensive Technogenic Load on the Environment

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The most intensive influence of technogenic factors complexes on the ground waters are observed in the territories of Baku and Sumgait. The increase of water service and existence of specific geo1ogical conditions sharply changed the hydrogeological situations mainly the balance structure and the ground water regime. The intensive rise of ground water level caused the flooding of significant areas and the development of a number negative processes.

The analysis of ground water formation regime showed that this process is the result of two factors of influence natural and technogenic Moreover, in the natural conditions being the background the certain 1ong-term direction in the hydrodynamic regime change hasn't been revealed. It has been revealed that the all changes are stipulated only by technogenic influence. It has been determined that the formation of ground water happens under the influence of six independent factors and eight different combinations. The influence degree on the ground water regime are changed in the wide ranges and determined by balance calculations.

The investigation results allowed us to work out of the complex of special hydrogeological maps for studied territory. It is revealed that uncontrolled loading on the

ground water causes great damage to the economy of Azerbaijan cities and demands urgent measures for negative processes liquidation.

The Evolution of Seismic Danger to Baku City in Relation with Ground Water Hydrodynamic Regime Change

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It is revealed that the statistically reliable trends determined in the ground water level regime stipulated by intensive technogenic influence on the ground water. The trends value are changed from -0.03 till +0.63 m per year for Baku territory. For some points their raising makes up more than 20 m.

The special hydrogeological maps characterized the depths of ground water position for different periods including prognostic estimation for 2005, and also a map of long-term changeabilitv of depths of ground water position for the period 1955-1995 were compiled due to the revealing of hydrodynamic indices of ground water regime and their level condition.

Seismic danger to the territory of Baku stipulated by the earthquakes of local and remote sources of Great Caucasus, Caspian sea area, North Caucasus, Kopetdag and Alburz.

It is determined that the local and remote earthquakes are felt on the territory of Baku by intensity of VI-VII degree of MSK. The calculated intensity of background seismicity and magnitude of maximum earthquake made up VIII degree of MSK and M=6.5 correspondingly. The intensity augmentation stipulated by underground water level rise on Baku territory for the different periods and also for 2005 had been calculated.

The dynamics of intensity augmentation changes had been determined for the first time according to that all areas of different intervals of intensity augmentation that have a tendency towards increase.

Systems Approach for Assessment of Renewable Ground and Surface Water Resources -Minnesota Example

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Quantitative assessment of renewable ground and surface water resources approach has been developed in the former Soviet Union in late 1950-th. This approach is based on integration of geologic, hydrologic and geographic information and provides unified analysis of ground-water and surface water runoff for mappable units. The entire

territory of former Soviet Union (more than 1/6 of entire Earth land territory) is covered with maps of ground water resources at a scale of 1:5 000 000 to 1:200 000. The general pattern of ground water runoff distribution [mm per year per square kilometer] on these maps is in good agreement with the patterns of landscape, geomorphology and hydrogeology for any territory.

Similar approaches to quantify surface and ground water resources were used in the United States for State of Minnesota. The map of river resources was created using system analysis and GIS. The pattern of river runoff values (from 0.19 to 0.91 cfs per sq. mi.) on this map exhibit close relationship to landscape, geomorphology and hydrogeology. Comparison of yields of runoff values and water use data per county for1995 varies from almost zero to four hundred percents.

Rum River watershed (1360 sq. mi.) was selected to demonstrate the feasibility of quantitative mapping of ground-water flow in Minnesota. Hydrographic system is represented by major rivers, tributaries, lakes and wetlands. The hydrogeological system is represented by two major hydrogeologic regions reflecting ground-water runoff conditions: Precambrian Crystalline Basement and Paleozoic-Middle Proterozoic Artesian Basin. Both these regions are covered by Quaternary deposits.

The ground-water runoff is shown by February mean runoff. For Rum River watershed the gauging station near St. Francis was used as bench-mark analog. It is the longest observation station in the watershed. Based on this bench-mark analog the short-term and random series of measurements are adjusted to the means of full period 1934-79. The range of minimal monthly values of ground-water runoff is from 0.038 [cfs per sq. mi.] to 0.205 [cfs per sq. mi.]. The statistical techniques (Fisher and Student criteria) are used to characterize every units of hierarchical hydrogeological subdivision. The ground-water runoff are shown on the map [cfs per sq. mi.] for five groups: <0.05, 0.05-0.07, 0.07-0.1, 0.1-0.2, >0.2. The reported water use for 1995 in ten counties covering partially or entirely the Rum River watershed changes from zero [cfs per sq. mi.] (Itasca) to 0.36 [cfs per sq. mi.] (Anoka) for surface water and from 0.0003 [cfs sq. mi.] (Aitkin) to 0.09 [cfs per sq. mi.] (Anoka) for ground water. The water use within the watershed is estimated to be up to 60% of surface - and to 30% of ground water resources.

The system approach provides realistic numerical values of renewable groundand surface water resources. This technique is applicable for detail studies such as counties and watersheds at local level, as well as for States and nations. Such maps would be particularly useful for National Water Quality Assessment Program. Subsequent comparison of renewable water resources and water use data will highlight stressful areas that need to be prioritized for water quality and quantity management decisions.

Water Withdrawal Estimates and Trends, 1950-1995, and Withdrawal Projections, 2000-2040 for the United States

Wayne B. Solley

After continual increases in the withdrawal of the Nation's surface and ground water from 1950 to 1980, withdrawals declined and remained ready constant since the mid 1980's, despite a continuous increase in population. The 1995 estimate of total withdrawals (402,000 million gallons per day) is 2 percent less than 1990 and nearly 10 percent less than 1980, the peak year of water use documented in national compilation reports prepared once every 5 years since 1950 by the U.S. Geological Survey. These trends are largely encouraging. These compilations are based on various sources of data

from which the findings in this abstract are derived. Water withdrawal projections, based on the historical trends in water-use determinants, indicate that if past trends continue, freshwater withdrawals in the U.S. over the next 40 years will stay below 10 percent of the 1995 estimate, despite a 41 percent expected increase in population.

The public supply, and rural domestic and livestock water-use categories are the only categories to show continual increases from 1950 to 1995, largely because of continual increases in population. Withdrawals for thermoelectric power generation peaked in 1980 and remained nearly constant since the mid 1980's. Industrial withdrawals declined from 1980 to 1995 after remaining about the same for the years reported between 1965 and 1980. Irrigation withdrawals decreased from 1980 to 1995 after steady increases from 1960 to 1980. Irrigated acreage continues to decrease in the West and increase in the East. Average water application rates in 1990 and 1995 were well below 1975 and 1980 rates as a result of implementation of improved and more efficient irrigation systems and techniques and application rates in the more humid Eastern United States being lower than in the drier Western States. Total per-capita water use in the U.S. has declined since 1980 and is projected to continue to decline through 2040. This decline in water use signals that water use does respond to conservation, economic, and regulatory factors.

Cost, Quality, and Risk Management: Contaminated Groundwater Treatment and Reuse for Potable Water Supply

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Treatment of contaminated groundwater and use of the treated groundwater to supplement potable water supply has become increasingly common in recent years. Treated groundwater is a critical component of many municipal water supplies and groundwater extraction often serves to control or minimize the spread of groundwater contamination. Treated groundwater can be safe and cost effective however, the cost and risk associated with contaminated groundwater treatment and reuse, particularly relative to surface-water supplies, is not always clearly understood by the general public or regulatory agencies.

In southern California, treated groundwater is used by a number of municipalities to directly supplement potable water supplies. The systems for treatment of these supplemental water supplies typically involve air stripping and/or granular activated carbon techniques to remove volatile organic compounds (VOCs). Although the cost of treating contaminated groundwater is often considered too great to make its use cost effective, the additional cost of groundwater treatment to remove VOCs typically ranges from $15 to $30 per acre-foot while the overall cost of producing groundwater, including replenishment district costs, is normally less than #300 per acre-foot. These figures indicate that treatment costs for removal of VOCs are a minimal component of groundwater cost. Overall cost for surface water is typically about $500 per acre-foot.

The acute risk associated with treated groundwater is also minimal relative to surface water. Groundwater generally is of higher quality and has a lower risk of biological breakthrough is thus much lower for groundwater treatment systems. The relatively low cost and risk of treating contaminated groundwater make it a sensible supplement to public water supplies.

Environmental Aspects of Spring Water Development

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Development of natural spring water for purpose of obtaining and bottling the water for public consumption has become a lucrative business in many countries. There are important considerations when evaluating and developing these resources including:

1) reliability of flow rates,
2) quality of water and public health,
3) watershed protection,
4) development methods,
5) legal aspects and ownership,
6) cost benefit analysis.

These factors will be addressed by use of case histories including photgraphs of springs and extraction facilities.

Surface/Ground Water Interaction and Flood Management

A Model of Daily Surface Runoff in Central Asian Alpine Watersheds

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Two-component mathematical model of river runoff simulation in central Asia alpine watersheds is a subject of presentation. The first component is devoted to estimate the daily surface runoff, the second one convert surface runoff to river runoff hydrograph. Frame of the model is based on meteorological data, morphological characteristics of watersheds, and river runoff information. Thus, the runoff simulation method is developed based on the data of daily short-wave radiation, mean daily air temperature, and daily precipitation, where the elevation, aspect, slope, snow packs water retention capacity, amount of refrozen melt water, and ice melt under glacier's moraine were taken into account. Glaciers, moraine and non- glaciarized areas in the basin were delineated via a Digital Elevation Model. The method of simulation has been calibrated and validated in Ala Archa river experimental basin in northern Tien Shan. This basin is a representative Tien Shan alpine watershed, which has large numbers of glaciers and extensive hydro- meteorological and glaciological data. The surface water transformational model was calibrated on the basis of daily data during extreme dry, wet and normal years. The validation of the model utilized the time period from 1961 to 1965.

The transformation of surface runoff to river runoff hydrograph was described in terms of linear ordinary differential equations applied to elementary volumes over which water balances were defined. One method of hydrograph derivation is based on a so-called single-reservoir model. A second method of hydrograph derivation is based on a two-reservoir model. The parameters in both the single-reservoir and two-reservoir hydrograph derivation methods are estimated by the least-squares technique subject to a constraint imposed on the estimated total runoff volume. The more complex two-reservoir hydrograph model yields very minor improvements in prediction as compared with the single-reservoir runoff hydrograph method. The absolute errors of simulation increase with increasing annual river runoff. The simulated river runoff is less than real values during autumn-winter and exceeds the measured river runoff during summer months. During years with increased glacier melt flood the simulated river runoff underestimates the real values.

The accuracy of surface water runoff simulation was improved by the application of complex morphological parameters (e.g. slope, aspect, and elevation) in the calculation of snow and glacier melt based on solar radiation characteristics in comparison of simulation based on air temperatures. Using seasonally variable parameters instead of constant annual parameters also decreases errors in simulated river hydrograph. River runoff simulation in alpine river basins with considerable glaciated areas was improved by using different sets of model parameters in the winter and summer seasons. Investigation of the possible methods runoff improvements in alpine watersheds will be also discussed.

Pragmatic Approach to Streamflow Time Series Generation

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Continuous daily streamflow time-series are required in a variety of hydrological analyses and water resource assessment practices. The paper will attempt to illustrate the concept of pragmatic hydrological time series modeling at ungauged sites and at different scenarios of catchment development. The key characteristic in the approach is a flow duration curve (FDC), which displays a complete range of discharges from low flows to flood events and represents a relationship between any discharge value and the percentage of time that this discharge is equaled or exceeded. FDC may be established at any site along a river. Its shape is determined by natural physiographic factors and affected by land-use type and state of the water resource development. The effects of these factors on streamflow may therefore be built in the curve itself, prior to the simulation of the actual continuous flow time series. A "natural" FDC for an ungauged site may be calculated using regionalisation techniques. The paper will present methods by which to adjust natural FDC to match with the current (or future) state of catchment development (e.g. in the cond ailable flow data from the nearby streamflow gauge(s), or rainfall data from rain gauges in a catchment. The approach is equally applicable for generation of both daily and monthly flow data and has been intensively tested and applied in a variety of water projects.

Flow-Duration Curves and Watershed Modification

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The flow-duration curve is a cumulative frequency curve that shows the percent of time specified steam discharges were equaled or exceeded during a period of record. All of the flow characteristics of a stream that range from floods to low flows are combined in one curve. In comparison to a hydrograph where time is on the abscissa, chronology not shown. Rather, the abscissa is scaled in exceedance probability values, which are used to estimate the percent of time that a specified discharge will be equaled or exceeded in the future.

The slope of the flow-duration curve when plotted on logarithmic probability paper provides very useful information about the geohydrologic characteristic of watersheds. Steeply sloping curves indicate 'flashy" streams where the flow is primarily from direct runoff and where there is limited ground water storage. Q20/Q80 flow-duration curve rations, which are obtained by dividing the discharge equaled or exceeded 20% of the time by the discharge equaled or exceeded 80% of the time, provide quickly determined measures of streamflow variability. In addition, the ratios can be used on watersheds of different size since they are dimensionless.

It is hypothesized tat Q20/Q80 ratios in urbanizing watersheds should increase as impervious cover expands and streams become flashier. This expected secular change depends upon the amount of impervious cover in the watershed.

Controls on River Channel Evolution Due to the Mechanical Continuum of Surface Water and Ground Water

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The mechanical interaction between flowing surface water and the adjoining groundwater system strongly influences the entrainment and deposition of sediment in flowing river channels. Where groundwater is overpressured relative to the surface water, sediment grains are more likely to be entrained, whereas where groundwater is underpressured relative to the surface water, sediment grains are less likely to be entrained. Pressure variations along the base of the channel created by variations in basal shear stresses, in conjunction with local groundwater conditions, control the relative pressure across the river-bed interface; turbulence (i.e. bed-normal flow) interacts with the resulting pressure gradient to control sediment entrainment.

Based on this analysis of fluvial sediment mechanics, the conditions for meander initiation, avulsion, and even channel morphology can be predicted. Meander initiation depends on the development of sub-channel groundwater flow patterns in response to shear-stress generated relative pressure variations. Avulsion depends on the development of overpressured groundwater conditions at the downstream end of the proto-avulsion during flood or near-flood conditions. River channel morphology depends on areal distributions of relative pressure variations, with U-shaped channels indicating significant sub-channel flow, and flat-bottomed channels result from relatively uniform relative pressures across the river-bed interface.

Groundwater - Surface Water Interactions Wetlands and Land Use Changes

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In humid regions, streams commonly receive groundwater, but in wetland areas, the wetlands may serve as an expanded and efficient groundwater discharge zone. In such an environment, storm peaks on headwater streams may result primarily from groundwater discharge. Land development may unknowingly impact the streams because the groundwater-surface water connections are not understood. At least three mechanisms make rapid groundwater discharge from wetlands possible: flow through an acrotelmic layer, confined groundwater beneath an organic mat with a possible system of pipes, and discharge from shallow basins with outlet control. The recognition of these conditions is important in mitigating the effects of suburban development and is illustrated by a case study of a shopping mall which would have impacted a wetland complex and endangered the habitat for a species of special concern.

Effects on River Hydrology from Overpumping of an Underlying Leaky Confined Aquifer: The Sparta Sand of Louisiana and Arkansas (USA) and the Overlying Watersheds

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The Sparta sand, a shallow (<200 m) confined aquifer in northern Louisiana and southern Arkansas, has been seriously overpumped for most of the last century. The potentiometric surface for the Sparta has decreased regionally, with maximum drawdowns exceeding 130 m. This decrease has changed the Sparta from a naturally overpressured (greater than hydrostatic) state that existed in 1900 to its current regionally underpressured (less than hydrostatic) state. The decrease in potential pressure within the Sparta has reversed the leakage across the confining Cockfield clays, so that the original outflow from the Sparta has now replaced by inflow to the Sparta.

The reversal of flow across the confining unit has changed the hydrologic balance in the surficial aquifers. Whereas the surficial aquifers used to receive a constant recharge from below, they now experience a continual loss downward. This has, in turn, reduced the water available for stream flow, as well as creating a deeper vadose zone, thereby reducing average river flows. These changes are most severe during periods of low precipitation when nearly all headwater streams are dry, but are evident even during periods of normal precipitation when most headwater streams only flow during actual heavy rain events. The net effect is to change the riverine systems of this region of high average precipitation (~140 cm/yr) into ephemeral streams with the hydrologic characteristics of semiarid riverine systems.

Optimized Regional Operations Plan for Wellfield Management

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Tampa Bay Water was established by the Florida State Legislation to develop, store, and supply water to its Member Governments in the Northern Tampa Bay Tri-county area. In June 1998, the agency signed the Partnership Agreement with the Southwest Florida Water Management District (SWFWMD) and the member governments to end decades of water litigation. The Optimized Regional Operations Plan (OROP) is a part of requirements to obtain the new consolidated water use permit under the Agreement. The Operations Plan will outline the production schedule among the Agency's 11 regional wellfields in such a way that effects to nearby wetlands and lakes will be minimized. An optimization model has been developed to maximize ground-water levels at a selected set of monitoring sites. Variations in water levels for a forecast period are accounted for by applying preferential weighting to monitoring sites according to their prevailing ground-water levels compared to established target levels. Current formulation includes the following constraints.

(1) Meet demands for delivery of water at Points of Connection to Member Government system.
(2) Meet regulatory requirements for production limits and minimum ground-water levels.
(3) Operate within physical constraints of the agency transmission and treatment systems.
(4) Account for spatial and temporal variability of rainfall influences on ground-water levels. The solution provides weekly pumping rates at each production well for the forecast period and the resultant transmission network flow to the Member Government Points of Connection.

Details of the optimization model formulation, solution technique, and its implementation will be discussed.

Assessment of the Ground Water Intake Impact on the Environment

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Intensive ground water use leads to re-forming of water balance in the vast areas, to reduction of soil and confined water levels, to river flow reduction, to changes in water/air balance of the soil root layer. It causes in its turn small river drying out, low productivity of arable lands and forests, deterioration of water protective and recreation roles of forests, degradation of soil cover.

The Laboratory for Ground Water Development and Protection of the Central Research Institute for Complex Development of Water Resources elaborated the quantitative criteria for ecological conditions of nature/territorial complexes elements, connected with the ground water level regime changes, methodical approaches to assessment of hydrogeological condition changes impact on nature ecosystems (stress and reservoirs, forests, arable lands and soil); the Laboratory also elaborated the Multifunctional Automatic System of ground water flow modelling and assessment of intake impact on environment MAS "GroW & MA". The system has a modular structure and consists of three subsystems: initial models construction, geofiltration calculation, planning of water resource use and environmental protection. By means of MAS "GroW & MA" special ecologo/hydrogeological researches on assessment of intake impact on environment in the city of Minsk were carried out.

The above mentioned researches made it possible to evaluate the main sources of intake operational supply forming from the quantitative point of view, to characterize the ground water level reduction dynamics in the adjacent areas, to define the shape and dimensions of depression cones of soil and confined aquifers and to assess the dependence of nature ecosystem and engineering object conditions from the operational water intake regime. The prognostication modelling enabled to define the zones of the negative water intake impact on natural ecosystems and to propose the complex of nature conserving measures which include more precise definition of the prospective construction plan in Minsk, of the operational regime of engineering objects arid some other preventive and organizational/technical solutions on rational use of natural resources.

Review of Current Stormwater Design Practices

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Drainage design addresses a wide range of complex situations, therefore there are a wide range of drainage design technologies are available. The number of design technologies available, however may impede development of a solid understanding of the basic design methods. This project was part of an EPA funded study to collect information on procedures used by drainage design engineers to design stormwater facilities. In this study, a survey was used to collect information from drainage engineers. Assimilation of information was accomplished through a questionnaire distributed to practicing engineers across the country. The questions asked in this survey pertained to methods of design, consideration of existing conditions, and use of regional site information. The goal of this study was to evaluate the level of technology in common

usage, and to determine some of the motivations behind the use of these technologies. With the knowledge gained from this survey, general-izations can be made with respect to the applicability of methods. Consequently, potential areas for improvement of drainage design practices can be identified. Municipalities and local governments can use these results to assess and improve their drainage ordinances and improve engineering practices. When we know where are methods are lacking, development of tools to ensure appropriate application of the various design technologies can be developed we can begin to develop new ideas, methods and procedures to improve current practices.

Urban Ground Water Management as a Tool for Wetland Restoration and Flood-Control

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This presentation will deal about the urban groundwater situation for different Dutch geomorphological conditions. The study will focus on the impact of urbanization on the natural (ground-)water system at a local and regional scale. Finally the restoration possibilities of the water system in existing urban areas will be discussed and new developments in spatial planning respecting (ground-)water and ecology will be presented. In the past centuries urbanization took place on the relatively high areas where groundwater levels are sufficiently deep to prevent marshy conditions. During the last decades urbanization encroached to the lower areas with shallower groundwater tables. For that reason, drainage of these areas was necessary and often the buildings had to be constructed on wooden piles. Urbanization in the higher areas as well as in the lower areas decreased groundwater recharge and increased rapid surfacewater discharge. Therefore, urbanization is one of the causes for two important Dutch water management problems, namely flooding in the downstream areas and drying-up of wetlands. Until recently, earth sciences in general and groundwater hydrology in particular were considered of minor interest for spatial planners, urban planners and architects. The advice an earth scientist could give was the adjustment of the surface water level or the depth of piles.

Interest in urban groundwater is increasing rapidly during the last years. The reasons are the afore-mentioned flooding and drying-up problems, and local problems in the urban areas as damage to constructions due to wooden piles partially becoming situated above the phreatic level; rising groundwater levels due to reduced groundwater abstractions for industries; and land subsidence elsewhere as a result of groundwater level declines. National and regional water managers understood that it is important to think in terms of integrated watersystems at different scales and levels. They started to stimulate a new attitude in urban planning with respect to the water system, minimizing damage of ecological values and minimizing changes in the local watersystem, adapting the design to the natural geomorphology of the zone to be developed.

Also in existing urban areas all kind of projects have been started in order to increase groundwater recharge or to conserve water as long as possible as a tool against flooding.

Perspectives on the Influence of Altering Surface Cover Conditions on Underlying Ground Water Systems

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Urbanization often produces deleterious and detrimental environmental impacts. Typically, these impacts are evaluated in terms of the increasing flood potential or degradation of water quality due to contamination. However, very little attention is given to the impacts associated with disturbance of surface coverage during urbanization. These impacts include prevention of groundwater recharge, alteration of the groundwater elevation, diversion of groundwater flow, and adjustment in surface water groundwater interactions.

This paper presents perspectives on the impacts associated with changes in surface cover. The effects of altering surface cover are documented from three sites. Case study site #1 illustrates the effects of reduced groundwater recharge to a sensitive wetland from the development of a parking area for a large regional shopping mall. Case study #2 documents how groundwater flow patterns are altered by changing surface cover conditions. The third case study illustrates how computer models can be utilized to predict groundwater impacts due to alteration of the surface cover. The results of the paper indicate that urbanization may have significant impacts to the underlying groundwater system and these ultimately may influence surface streams and ecological habitats.

Spatially Distributed Rainfall-Runoff Model for Urban Watersheds

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Digital terrain modeling along with the use of a Geographic Information System (GIS) describing the spatial variability of hydrologic parameters such as rainfall distribution, soil characteristics, vegetation cover, and land use has allowed the development of a spatially distributed rainfall-runoff model for hydrologic analysis of urban watersheds in Los Angeles County. The model has two integrated components: (1) the Watershed Modeling System (WMS) developed by the Environmental Modeling Design Laboratory of Brigham Young University (BYU), and (2) the Los Angeles County modified rational method. The WMS utilizes digital terrain data to delineate watershed and subarea boundaries, and compute geometric parameters such as area, length, slope, etc. The WMS can also use the GIS data coverages to develop hydrologic parameters such as rainfall distribution, runoff coefficients, and land use. The Los Angeles County modified rational method applies the basic rational equation to a storm of varying intensity. Through this application, a hydrograph can be generated at the outlet of each subarea. The estimate of time of concentration for each subarea is the critical parameter in the modified rational method. The kinematic method is used to estimate the time of concentration. The modified rational method is particularly suitable for urban watersheds where the surface runoff is the only component contributing to total runoff. The application of the rational method to large watersheds is not consistent with the underlying assumption that the rainfall intensity is constant over the duration and uniform over the area under analysis. Therefore, the rational method is applied, based on small subareas, to rainfall intensity being dependent upon the storm time and the time of concentration. The runoff coefficients that transform rainfall to runoff in the

rational equation are derived from infiltrometer tests. These tests are performed at several sites for each identified soil type in Los Angeles County. These runoff coefficients are spatially distributed, being dependent on soil type and rainfall intensity. The modified rational method uses the GIS data generated by the WMS interface to compute spatially distributed runoffs in a more efficient and precise way. The storage and channel routing feature of the distributed model allows the routing of the hydrograph for peak attenuation and hydrograph combining. The distributed model has been tested and the results are consistent with the Los Angeles County hydrologic requirements.

Minor Rivers of the Central European Russia and the Change of their Hydroecological Condition under Human Impact

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The paper is based on the results of the recent survey of a number of central European Russia's minor rivers. The complex field survey of minor rivers included hydrometrical, hydrogeological, hydrochemical and hydrobiological measurements in their channels and on their watersheds. Based on the analyses of the information, it was formulated that hydroecological problems can first be detected on the level of territorial and aquatic features of minor rivers. The influence of human activities on the formation and magnitude of the so-called "georunoff" - the runoff of surface and ground water, sediment transport, and the runoff of dissolved and biogenic matter - is clearly seen in the basin valleys and channels of small rivers.

An important step of the study was to establish the likeness criteria covering the areas with inadequate hydrological information. A point system of evaluation of the human impact on minor river watersheds in the area under consideration was developed, including such indices as deforestation, arable areas, urbanized areas, population density, sanitation and sewage, and water consumption.

Simultaneous hydrometrical, hydrogeological and hydrochemical surveys of minor rivers and their drainage basins allowed for the evaluation of groundwater inflow into the rivers during the low flow period when water quality is most vulnerable. Water quality evaluation was based on the comparison of field information with water pollution standards used in fish culture and sanitation. The results of the evaluation of natural water in the minor rivers' drainage basins reveals some zonal and man-made factors that determine concentrations of pollutants of water in nature. In central Russia, the rate of river runoff decreases southwards. At the same time, the population density and agricultural and industrial activities considerably increase in the same direction. As a result, the concentration of pollutants grows from the north to the south and in some cases, even exceeds water pollution standards. In evaluating the minor rivers' morphological condition, the likeness criteria applies such characteristics as the drainage basin area, the stream order in the tributary hierarchy, seasonal flow distribution, morphology of river valleys and channels.

The survey of minor rivers of central European Russia was undertaken by the Project K0650 of the Federal program "Integration". The activities of the Project will be continued in 1999 and 2000.

Management Rules for Multiple-Purpose Reservoir during Emergency Flood

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The operational management method is offered for multi-purpose water reservoirs with the aim to decrease the probability of the emergency flooding and to improve the ecological conditions below the dam during big cloudburst floods.

The operation management rules for water reservoirs have been worked out with the help of an incorrect probabilistic model of flood flow. The model has been performed using the total number of conditional probabilistic functions of discharges for each internal year interval according to simple Markov chain. The new management rules have been checked with the example of an imitation model of water reservoir work. This model has been worked out on the foundation of the well-known Svanidze's fragment method, which consists of the double Monte-Carlo imitation of the annual discharges, and the internal year interval discharges.

Comparative estimations were made with the help of the imitation model and the example of the real flood of small probability, which took place during 1980 in the Caucasus rivers. The results received have shown that the maximum discharge below the dam may be decreased and consequently, the ecological conditions may be improved. In that time, the probability of the water consumption plan is constant, real water consumption is increased and average damage from the water deficit is decreased. The model has been tested on the Krasnodar reservoir in Russia.

Lake Baikal - The Controlling of Water Storage and the Apple of Discord

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Lake Baikal is the Earth's biggest reservoir of fresh water. Its water surface is equal to 31,500 km^2, maximum depth 163.7 m, water volume 23,000 km^3. But now this potential world source of potable water is used to regulate inflow to a chain of reservoirs on the Angara-River. This chain of hydropower plants (HPP) includes 3 steps: Irkutsk, Bratsk and Ust-Ilim: the fourth Boguchan HPP is under construction.

The Irkutsk dam, built in 1956, converted the largest freshwater lake into the reservoir regulator of Angara River discharges. Theoretically, Baikal could provide the following functions: seasonal and year-round water flow redistribution in the interests of the power generation, navigation and flood control in the Angara valley.

However, in reality, it has been found that the simultaneous realization of the above mentioned functions is impossible because the deep draw-down of the Irkutsk reservoir. Also because Lake Baikal leads to the decreasing of water discharges through the natural throat (gorge) of the Angara and, as a consequence, there is a substantial drop of the Irkutsk HPP firm power output and a deterioration of Angara shipping conditions downstream of the Irkutsk dam. The rise of water levels upstream of the Irkutsk dam provokes a rise of water stages in the lake and flooding of the coastal strip (with accompanying damage to the agriculture of the Buriatya Republic and an unfavorable effect on the valuable endemic fish (omul) spawning and reproduction).

During the first decades of the Irkutsk HPP operation, because of the population's false feeling of hydrological safety, of regional authorities built the new country houses and child welfare institutions on the Angara flood lands downstream of the dam.

This necessitated decreasing maximum flood discharges from the Irkutsk reservoir to avoid the flooding of new urban territory. Such a reduction in maximum releases in each turn requires a more frequent and higher superelevation of the normal supply level of the Baikal. With the superelevation of more than 0.5 m, the Krugobaikal railway road-bed and floor is prone to scouring and destruction. Simultaneously, the damage to the Buryatya territory tends to increase.

These interregional and interministerial contradictions and their resolution are the subject of the proposed presentation.

Present Condition of Reservoirs in Uzbekistan and Ways of increasing their Functioning Stability

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Creating reservoirs to regulate the rivers flow with dams has solved many water-economic problems. But a number of new problems has appeared such as washing the river beds away in the down stream of the dams, lowering of the rivers capacity in connection with intensive economic use of their flood-lands, the ecological deterioration in the areas of the reservoirs constructing (flooding and swamping of the territory, etc.)

There have been constructed about 50 reservoirs in Uzbekistan, each of them has a capacity of more than 1 mln. m3 and their total capacity is about 15 billion m3. Most of them were put into operation 20-50 years ago so the problem of the reservoirs stable functioning has become an urgent one for the time being.

Generalization and analysis of long standing nature investigations and observations by the scientific and designing organizations show that the older the reservoirs, the less reliable they become which is demonstrated by some accidents and breakdowns. One of the most important elements of reservoir working stability is a grade of its filling with silt. The present labourous content way of the grade determination is recommended to be replaced by airospace sounding. The experience of this method use is shown on the concrete example.

The report analyses the technical condition of 17 large Uzbekistan reservoirs and the reasons which have lead to the present situation: rapid filling of the reservoirs with silt, washing the banks away and their conversion, hoisting lifting gear faultinesses of water gates and checking and measuring apparatures, ill-timed repairs out and their unsatisfactory quality.

The ecological losses are assessed on the example of an accident occurred when high water passed in a small river which can be a model for big dams.

Some recommendations are given and the ways are shown to change the situation, to increase functioning stability of such hydrotechnical constructions.

Ecological-Economical Assessment of Uzbekistan Reservoirs

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Actuality of ecological-economical investigations of Uzbekistan reservoirs is stipulated by the following circumstances: the first, current investigations have been done within one or another problem solution. The second, up to now there have not been complex economic-geographical evaluation of little and middle-sized reservoirs influence to environment, development and location of the producing forces o£ adjacent territories.

Societal-economical tasks which the Republic is facing now, requires further ecological-economical analyses of reservoirs affection (positive and negative) to environment, economical development, population setting, and also basis for perspective changes in interaction of natural and economical factors in the reservoirs influence zone.

All of it requires to:

- **study the societal-economical factors of reservoirs construction;**
- **make complex analyses of the reservoirs influence to environmental components, such as: microclimate, soil and vegetation, relief-creating processes, fauna;**
- **investigate peculiarities of societal-economical development of the region in connection with reservoir construction works, on the basis of improved methods of assessment of reservoir impact to elements of infrastructure and population setting;**
- **distinguish main directions of future development of the producing forces in the reservoirs influence zone in general and for the investigating region;**

For ecological-economical evaluation of the reservoirs use and protection we have offered a complex method based on conjugate studying of natural-climate and societal-economical aspects of the reservoirs impact. By applying such a method the achieved results can be used by diverse projecting, researching and economical organizations in solution of current and perspective tasks.

Water and Agriculture

The Basis of Water Arrangement of Central Asian Deserts

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The stable development of Uzbekistan under the conditions of economic, water-supply, ecologic and demographic tension is connected mainly with use of almost entire water resources, their significant contamination, the Aral Sea drying, the desertification processes increase.

When estimating the water resources under the existing conditions it is necessary to switch-over from the method of water-economic balance to the method of the area water balance enabling to use the agricultural potential of the deserts.

The long-term purposeful studies and experiments in the key-problems of the deserts, i.e., hydrogeology, hydrophysics, hydrometereology and water-saving have been carried out in the Institute of Water Problems of the Uzbekistan Academy of Sciences under the guidance and with participation of the authors, in collaboration with other Institutes of the Republic and the CIS; it allowing to settle the problem of water-supply as a complex one using water resources of different quality.

- the theoretical basis and the technology of regulation of evaporation from water surface and irrigated plantations in the quazistationary electric field have been developed. The effect: evaporation velocity is reduced by 15%-20%, increase - in more than 3 times with insignificant power expenditure;
- the principles of district-dependent water collection in the deserts according to the amount and intensity of atmospheric precipitation and the technology of increasing the drainage of temporary water-flow have been worked out as well as the ways of moisture-saving in soil;
- the sites of possible underground water storage have been determined;
- the method and the system of using the moisture of atmospheric precipitation to irrigate some dry-farming land and pastures with the norm of 80-90% have been developed;
- the method of salts electro-ionic exchange has been worked out and experimentally tested to use highly mineralized water for irrigation;
- the method and the device for micro-dispersed moistening with evaporation of waste (marine) water reservoirs have been developed to reduce sweet water expenditure in 3 and more times.

All the above said and other elaborations of the Institute are protected by the patents of the Republic of Uzbekistan, Russia and allow to create an aqua-network of the deserts on the basis of the local water resources.

Water Conservation and Environmentally Safe Technology of Soil-Melioration and Other Factors of Crop Growing on the Base of an Autonomical Irrigation-Drainage Module

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In the Aral region from the total irrigated area more than half have the different level of salinity, as 31% of soil is small salinity, 22% is middle saline lands, 10% high salinity. Type of salinity in most cases chloride —sulphate. The medium score of soils is the *58* (in 100 score system), from which the lands under medium level of fertility *569* 000 ha (17~6%), close the medium level 970 000 (28.6%). The crisis began at the basin of Aral sea, which was before one of the largest sea in the world. Jn result of wind action every year more than 100 million tone of toxic salts spread on the Central Asian territory.

The population of Aral zone under action of this great disaster increase (30%) the level of infant and mothers death. On 20% increase number of hephatite, scene cancer. For decreasing of level of ecological disaster can be by extend of safety irrigation technology, which basis on new point of view to the parameters of melioration monitoring and differential regime of irrigation of agricultural crops, which basis on the decreasing of level of ground water levels from 1 and 2 meters each *0.5* m and quick changes of dates and norm of irrigation. Investigations, which were conducted on the standard for looked area- Khorazem oasis on total area 710 000 ha, where for growing of agricultural crops using 14.5 billion cubic km of water in year, with 14000-16000 cubic m per ha irrigation norm, results showed, that irrigation with differential irrigation norm with 3300-7900 cubic m per ha and with norms 900-1200 cubic m per ha (with parts on two-three times), calculated on basis operational calculations on deficit of soil moisture up to the *o.5* m to the ground water level. Forever most of the toxic salts in soils of this region accumulating in the non-irrigation period, after this period (September-March), most effective melioration method is the autumn — winter washing of soils by watering with norms 1500-7000 cubic m per ha relating the hydromodul district. The recommendations permit on 15—20% to decrease the volume of water taking, to increase the yield of agricultural crops 10-12% and to improve the ecological conditions without material and labor spending.

Hydroecological Problems in Uzbekistan - Modernity and Perspective

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Uzbekistan is a country of the irrigated farming agriculture, which has some peculiarities of river (water and salt) flow transformation occurring as a successive chain of irrigating water transformation. In the paper this chain is presented as a structural scheme. The main points of the scheme include water intake from the source of irrigation, water flowing along the channels in the cultivated lands. It provides widely spread redistribution of the river flow, penetrating into the soils and rocks in the aeration zones, and filtration in the salt affected water zone, accumulation and flowing in the water reservoirs. The reverse connection in the chain appears between aeration and water saturation zones at the expenses of capillary water and by using return water for irrigation. One of the possible variants of the complex usage of surface and ground water, in some way taking into account natural structure of the Fergana Hollow is its high-altitude-zone structure. The general idea of such a solution is the cascade-area distribution of the irrigated massifs along the high-altitude zones of the hollow. Irrigated massifs with their hydro-meliorative systems locate along the relief slopes in such a way that the water carrying from the upper massif can be used for the down massif irrigation, and in the case of water deficiency or necessity to dilute it can be used for replenishment

from a channel of a big river or water reservoirs. Described river flow transformation condition has stipulated developing of a new hydrological branch - meliorative hydrology. Productivity of the irrigated farming agriculture and environmental conditions in many ways are predetermined by problems solved within this direction. There are elaborated in the Institute of Water Problems some methods based on the integrated approaches in water and salt flow management. Methodical process of water and salt flow integrated management realizes in meliorative hydrology on the base of hydraulic model. The main point of such a model is realization of the real fact of the water volume variability and substances mass dissolved in the river systems. The perspective of the presented method assists decoding of the regional water objects ecological crisis and can be applied for monitoring and hydroecosystems management on the whole.

Use of Rainfall Data as the Index for Irrigation Requirement for Crops

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Only rainfall data can be successfully used to determine the irrigation requirement for a crop. Rainfall pattern in a region affects hydrology, geomorphology, soils, fauna and flora of an area. Conventionally potential evapotranspiration for a reference crop is determined by using an empirical formula that may need hydrologic and meteorological data such as cloud cover, wind velocity, solar radiation, evaporation, temperature, vapor pressure gradient, psyclirometric data, etc. Then the coefficients for a crop are determined with reference to the reference crop at various growing stages. Effective rainfall is subtracted from the potential evapotranspiration to determine the irrigation requirement for the crop. However, to determine lie effective rainfall for a crop in an area needs much more data concerning hydrology, soils, geomorphology, land use, etc. Au these parameters and data are expensive and time consuming to collect. In most cases, they are not available. To avoid all these expensive and time-consuming procedure, only rainfall data is used in this paper to determine the irrigation requirement for a crop in a region. It has been found that very good relationship (equation) exists between rainfall of venous probabilities and irrigation requirement for a crop in a region. This analysis also can indicate how much irrigation water is required for a crop in a dry year, wet year and average year. The upshot of this technique is that it only needs daily rainfall data that is readily available for most of the locations.

The Potential of Improving the Management of Water Use

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The rational management of the processes of evaporation and watering of irrigated territory is an important goal of water use managers in the arid areas of Central Asia.

Results of investigations and variations in management of agricultural water use are presented. The goals are the improvement of: water use efficiency, regulation of water flow, and rate of application and infiltration under which water can transport agricultural chemicals applied to irrigated lands.

The authors conducted the research in the optimization of methods of irrigation using a new ecologically safe hydrofoil and hydrofoil polycomplex for regulation of moisture accumulation in root zone of soil in agricultural fields. In this scientific work researchers used the new high organic molecule hydrofoil complexes, called the supersorbent, concentrated at a depth 25-30 cm. The created hydrogel level can help to reduce the infiltration of water and chemicals into the upper tilled soil without impacting the grain size of the soil. The use of this hydro gel in soils where is has remained for a few days or a month or in conditions where the amount of infiltrating water was measured demonstrated a real potential for regulating the water content of soils in agricultural.

Investigations were also conducted in which the polycomplex material was placed in the bottoms of irrigation furrows in cotton fields. Results of investigations showed, that with injection of the polycomplex solution (3%) at a depth of 0.5-0.81 m below the surface, the depth to which irrigation water infiltrated in sandy-loam was decreased by a factor of 4-5 times where 850 cubic meters of surface water per ha were applied over a period of 6-7 days. Researchers also monitored the prolonged affects of the presence of the polycomplex on chemical element and nutrients concentrations from fertilizer during the growing season.

The results of this research show that the polycomplex can be used to optimize the rational use of fertilizers and the minimum amount of irrigation water needed to infiltrate the soil.

Principles of Water-Salt Regime Management of Irrigated Lands under Water Scarcity

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Water scarcity, its quality deterioration and salinized soils conservation in more than half of irrigated lands under low technical state of hydroreclamation systems (HRS) complicate water-salt regime ("w.s.r") management and HRS operation. In this work we consider only technological principles of the management. Conceptually the water is regarded as a limiting factor because of its scarcity and all the management methods are based on water saving. "W.s.r." management problem should be considered from the general positions of management theory and should take into account current development of cybernetics, computer science and informatics.

Through an optimal "w.s.r." in the soil, aeration zone and ground waters the technological methods of water-reclamation activity interlinking with crop productivity and nature-conservation requirements within the general system of agricultural production are being improved in course of time and space. Rationalization of material and technical resources use during operation and rehabilitation of hydroreclamation systems are based on the optimal "w.s.r." provision.

As a base of "w.s.r." management system the water-chemical balances are taken. Other regularities of the system are used during balance's elements definition or are drawn from a mathematical system.

Generalization of lomg-term research gives recommendations on optimal limits of "w.s.r." regulation under various nature-economic conditions. The methods for introducing inventory of reclamation state of the irrigated lands; "w.s.r" management methods under HRS operation and calculation base of operation and maintenance measures for drainage systems are improved.

Technological principles for creating computerized information base of "w.s.r" management and proposals on existing irrigated agriculture's manage-ment structure improvement are substantiated.

Temporary Surface Drainage in Central Kyzylkum and Concepts of their Assimilation

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The source nutrition for temporary waterdrains in Central Kyzylkum are rains and sometimes thawed snow water. Supervision over formation of a drain (G.T. Leshinsky, 1963) shows that on water gates, combined takir and takir sort soils, the precipitation in quantity up to 3-5 mm for period of one rain does not usually cause a drain. They are completely spent on infiltration and surface detention in microfall comprising, so-called initial losses of a drain. At very damp soil or at downpours initial losses are several times less. So, precipitation in 5 mm with intensity 0,10 mm / mm already form a drain.

According to the data of Gidrometcentre the greatest relative number of cases drain-forming rains (8,5-14,3 %) is observed at precipitation in 5-10mm, at precipitation more than 20 mm it is a little bit less than 2%. The number of drain-forming rains with precipitation more than 5 mm makes from 3 up to 8. Conducted calculations by the method of Alushinskaya N.M. (1959) of possible collection of atmospheric precipitation at their various intensity in the area, located between mountains Kuljuctau and Auminzatau. It is shown, that volume of a surface drain for one rain (sum of precipitation of -10 mm, the average intensity of a rain - 0,5 mm/min) from water gates with the makes about 518 thousand m super 1ang2057 waters; from the same area at intensity of a rain 0,1 mm/min, it is possible to collect up to 1296 thousand m of water. Similar calculations are carried out for areas with various lithological structure, at various sums of precipitation per rain, at different its intensity and different on the occupied area water gates, in various geomorphological conditions of Central Kyzylkum. Use even of an unimportant par of potential water resources would allow to improve, in a number of regions of deserts to organize steady drinking and pasture water supply.

Peculiarities of the Regional Water Resources Management in Central Asia

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Amudarya and Syrdarya rivers with their tributaries form the unit system of the Aral sea basin. Total reservoir's capacity exceeds 60 km^3. Total water divertion from Amudarya and Syrdarya rivers varies from 73.4 to 89.8 km^3/ year. In 1989 Aral sea volume was 354 km^3, in 1997 it became 210 km^3 with reduction on 144 km^3. Within the region as a whole groundwaters as local sources form about 25% of river flow. Throughout the region surface and groundwaters quality deterioration from upstream to downstream occurs. Return waters form about 45.8 km^3/year and are serious source of pollution.

Main reasons of water resources scarcity are: high rate of population growth-2.3% /year; irrigated areas expansion - 7,95 mln.ha; low efficiency of canals: interfarm-0,80-0,83; onfarm-0,70-0,74, irrigation (in particular into furrows, stripes and checks) - 0,61-0,63; leaching irrigation regime (more then 55% of irrigated lands are salinizated in different degree) on base of drainage (more then 4,2 mln.ha); imperfect management at onfarm level.

Interstate level of water management: International Fund of Aral sea saving (IFAS); Interstate Water Coordination Commission (ICWC); Basin Water Organizations (BWO "Syrdarya") and (BWO "Amudarya"); Scientific-Information Center (SIC ICWC).

At the national level, there are governmental organizations of water management: Ministry of Water Resources (Ministry of Agriculture and Water Resources, Committee on Water Resources), oblast and districts departments of water management, water users; specialized units maintaining large waterstructures, scientific, design and construction organizations, as well infrastructure (transport, energetic, industry, staff training and etc.)

Methods of water resources improvement and management: institutional aspects-transition to complex irrigation-basin systems of management, as well as to half-autonomous market organizations at the lower and local level; investment aspects which need the least expenses- reconstruction of small structures, leveling of irrigated lands; investment aspects which need capital expenses - construction and reconstruction of pumping stations, reservoirs, complex irrigated lands reconstruction, introduction of progressive technique and technology of irrigation (sprinkler, drip irrigation etc.).

Technogenic Structure of the River Syrdarya Basin Flow and Management of the River Water Quality

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"The natural structure" of the basin flow had been revealed in 1930-s. The following transformations including changes in both quantity and quality of the river water and interrelated with it underground water had been also retraced.

However, two interconjugated aspects of the problem, i.e. the flow's technogenic structure and the entire basin's technological schema of management of the water quality are still interpreted insufficiently. The working hypothesis of interpretation is as follows.

The flow's technogenic structure is the ratio of quality and quantity of the natural genetic constituents transformed by economic activity and those formed under its impact.

It characterizes the guided hydrological, hydrochemical and hydrobiological conditions of interacting parts of the basin.

The entire basin's technological schema composes the essence of hyrotechnical organization of the water-supply system and the complex as a united object of integrated management providing fresh water to let through to the flow's natural basis.

Epignosis of the natural structure showed that the underground feed of the river in the last range of the upper stream (Fergana) had attained 2%, that of the middle stream had been 5, while the salt analogues in water of satisfactory quality had been 25 and 40.

In the technogenic structure: quality was unsatisfactory, the above-mentioned characteristics were 32 and 78, 78 and 87%. The cause of this was the autonomous technological schema of the existing system of "management" of irrigated land drain which does not control the salt factor.

Elimination of this defect, as it was shown by calculation experiments and modeling is possible by introduction of a new technological schema of hydrotechnical organization, i.e. the cascade-area subordination of irrigated land as well as by reconstruction of melioration erections. The schema allows 6 km^3 of fresh water to attain the lower reaches in an average by water-amount year. In principle, the problem of management of the river Syrdarya water quality has its solution that is shown by the presented interpretation of the flow's technogenic structure.

The Peculiarities of the Meliorative-Hydrological Processes in the Basins of Syrdarya and Amudarya Rivers and the Regulation of their Water

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The long-term theoretical, experimental and laboratory research work on meliorative-hydrological processes in the region and forming the water quality of the large rivers is generalized in report. It is ascertained, that the processing of the meliorative-hydrological processes causes the transformation of the river water to returning flow. The typical peculiarity of the proceeding of the meliorative-hydrological processes in region is the increasing of the unreturned consumption of the river flow to such limits, that the damage is done not only to large water objects (Aral and other), but the biggest consumer plant-growing. The last is conditioned with the negative changes of the water quality. For the first time, on the base of water salt balance and economical calculations are shown the reasons of worsening the meliorative state of irrigated areas and the size of economic damage connection with the quality of water in coordination with the waterness of year and growth of mineralization along the length of the river from the upper reaches till the lower reaches.

The determined quantitative estimation of correlation of the transformation of the water and salt flows and their inter-conditionality allowed for the first time to formulate the principle double minimization of the damages to the river flow both water volume and salt component.

For the first time basin technological scheme of regulation the quality (de-mineralization) of river water developed on the base of principle double minimization is suggested for SyrDarya and AmuDarya. The main ethnical and technological scheme of decisions are concentrated on operational measures of water and hydromeliorative plans. In the number of such measures the most important for the dry years is the suggested

phase displacement and distribution to stems of large/middle rivers, terms of conducting of moisture drilling and reaching in water industry districts.

The important part of developed technological scheme is the regulation of the river water quality and it is the technical decision using the brackish return water in the place of formation. The technical decision and technical methods on realization of the given measure are worked out in this report and the most important thing is that, on the base of long term experimental research work, the conditions for their realization is established. The developed and suggested technological scheme of regulation and decreasing the volume of collector drain age water allows to cut the mineralization of the river water in the zone of intensive consumption of the flow up to 0,7-0,8 g/l against 1,8-2,0 g/l.

Quality of River Waters of the Aral Sea Basin: Problems of Estimation, Management, Improvement and the Ways of their Solution

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Laboratory of hydrochemistry of JWP since 1991 year conducts the investigations of estimation of quality of river waters of Aral sea basin, influence 2005-2010 yy., elaboration of methodic and revealation decisions of this problems.

Now in laboratory there is Bank of hydrochemical data by river waters of Aral Sea basin, from 1938 to 1998 years , and also Bank data of river flowing". In addition this it is collected the data of pollution of collector-drainage and industrial sewage waters, dischanging into rivers. Also it is collected data about of development of economics in republics of region for perspective, with calculation increase of areas, with irrigating agricultural cultures. It is collected data of sockrate of population native in different regions per five years for revelion tie between quality of drinking water and health of the population.

Processing of collecting data by using different methods of calculation and analyses (statistic, correlation, graphic, cartographic, model and other) allowed to receive following results:

to calculate mean quality of five years the exceeding different elements by different river's posts, beginning from source to mouth;

to reveal the tie between quality of water with water's regime of river on the individual post. With determine matematic depedence;

to offer method of estimation of water quality, calculating the antropogen factors;

to compile hydroecological map on the Aral sea basin, with calculation quality of river water and sickrate of population;

to show the possible of management of quality of river waters using the example Chirchik river basin.

Use of a Model Based Hydroecological Monitoring for Managing the Aral Sea Basin

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This article examines an example of the problem of selecting and making use of environmental monitoring technologies that take into account the arid climate of Central Asia. The high human population growth rate makes the paucity of water resources within the region and arid climate of paramount importance within Uzbekistan. The intense use of water resources within the Aral Sea basin for agricultural, industrial, and waste water needs has resulted in contamination of water resources by a diversity Of hazardous chemicals from anthropogenic sources. Another consequence has been the catastrophic lowering of the level of water in the Aral Sea as a result of the greatly reduced flows in the Amudarya and Syrdarya Rivers. Contamination of water has influenced the health of the area ecosystems - soil, flora, fauna, and the human population. Hydroecological monitoring has become critical because the people of Uzbekistan depend so heavily upon sparse water resources.

A basis for hydroecological monitoring has been developed that takes into account all anthropogenic factors as well as natural ameliorative processes. Important anthropogenic factors include agricultural practices, surface-water drainage collection, industrial practices, and municipal waste effluent. Natural factors include effects from indigenous rocks and soils, topography, vegetation, and precipitation (aridness). These factors can be included in a block model of the Aral Sea Basin. Data used to support the description of the study area are gathered from aerial photos, analyses of maps, and streamflow and water-quality analyses such as regression, correlation, and trend analyses.

An example of results is presented in a model of the part of the Aral Sea Basin where the Surkhandarya River joins the Amudarya River in the Syrkhandarya Region of Uzbekistan bordering with Afganistan and Tadgikistan. This complex method of hydroecological monitoring described in this paper, when applied to the entire Aral Sea Basin, can contribute to the rational use of the water resources of the entire Aral Sea Basin, especially during these times of water level dramatic decline in the water level in the Aral Sea.

Management of Collector-Drainage Water Runoff on the Right Bank of the Amu-Darya

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Discharges of the mineralized collector-drainage water are the main source of pollution and worsening of the Amu-Darya river water quality. Every year from the irrigation zone of Uzbekistan more than 2000 mln.m3 drainage water with mineralisation of 5-6 g/l and even more is discharged into river. Nearly 35% volume of all drainage waters, is discharged via main collectors- Yuzhny, Parsankul and Beruny. For the minimizing the salt removal into the Amu-Darya river and minimizing negative effect of water quality to the environment it is required to take ecological sound measures. In 1996 with the support of the World Bank Uzbekistan Drainage Project was started in order to work out of general strategy and alternative decisions on improvement in irrigation and drainage system. Certain work results on Project, are being implemented jointly with Mott-MacDonald- Temelsu firm and "Uzgipromeliovodhoz" institute is the aim of this

publications. Studyings are based on field works on key sections and regions, processing of informations and data base of various organisations, use of GIS- technology; use of river flow regulation model (Abdullaev U.V and Lutay V.N), CROPWAT, WATERREG and calculations of water management and salt balances and so on. Choose of alternative decissions were done for different scenario of development foe 2030, as well as on the limit of available water resources. Estimation of loading tendency from the pollution along Amudarya river showed, that water quality in the river considerably depend from the inflow of CDW and there mineralisation level. Middmonth distribution near Termez is vacillating from 0.9 g/l in january till 0.4 g/l in july, and in the downstream of flow accordingly - 1.2 g/l and 0.9 g/l with maximum in arid years till 1.4-2.0 g/l in March-April. With the runoff of the Yuzhny collector 3.4 mln.t salt, from Parsankul collector-4.946 mln. t and from the Beruni collector 1.880 mln.t salt is discharged into the river. Decreasing of Yuzhny collector runoff, as a result of divertion of 525 mln.m^3 CDW with mineralisation of 6,23 g/l into the lake Dengyzkul gives positive effect to the river flow and water intake from Amu-Bukhara canal. Proposed turn of Beruni collector changes of situation in majority part of Amu-Darya river downstream: improvement of draining, decreasing of inputs of water for irrigation and soil leaching, decreasing of mean and highly saline lands and stabilization of ground water level to 1,5 - 3,0 m with decreasing of middannual mineralisation of water in the river on 0.1-0.12g/l.

Climate and Climate Change

Regional Climate and Streamflow Studies Using the Regional Climate System Model

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We will present the Regional Climate System Model (RCSM), a hydro-climate and impact assessment modeling system, and its evaluations for the western U.S. and East Asian regions. This study is focused on a diagnosis and prediction of the seasonal hydroclimate for an application to flood forecasting and water resources assessment.

Regional hydroclimate has major impacts on the occurrence of natural disasters, available water resources and the health of local ecosystems. In the western US and East Asia, increasing populations, urban developments, and industrial activities have enhanced the impacts of the hydroclimate on human lives and local economies. The regional climate and its impacts on human society are significantly affected by local elements such as terrain, vegetation, and land-sea distribution in addition to the large scale atmospheric circulations. Therefore, accurate assessments and predictions of hydroclimate are important for water resources management, reduction of flood damages, and long-term development and conservation planning.

The RCSM has been successfully used in studies of the seasonal hydroclimate, weather, quantitative precipitation, and streamflow forecasts, and water resources for the western U.S. and East Asian regions. In this presentation, we will evaluate the RCSM in seasonal and multi-year hydroclimate hindcasts in the western US and East Asia. We will present results from a prototype 3-tire seasonal prediction system for the western US during the 1997-1998 winter season.

Numerical Analysis of the Effect of Climate Change on Aquifer Conditions in the Southeastern Hueco Aquifer, Chihuahuan Desert

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The geological, paleontological, and botanical record indicates that the climate as recently as 14,000 years ago was significantly wetter in the Chihuahuan Desert of the southwestern United States and northern Chihuahua, Mexico. Natural global climate fluctuations have occurred persistently through geologic time, and the Chihuahuan Desert has reached a period of relative aridity. At some point the Chihuahuan Desert will be displaced by wetter climates as a result of the normal cycle of global warming and cooling. The return to wetter climates, or proliferation of even drier climates, could be hastened by human interactions with the environment.

Most aquifers in the Chihuahuan Desert are not rapidly replenished by precipitation recharge, and depth to groundwater is often tens to hundreds of feet beneath land surface. Many of the land regions above these arid aquifers are being targeted for disposal of low-level radioactive waste, industrial waste, and municipal sludge. It is assumed that the great separation between land surface and the groundwater zone will minimize the risk of contamination of groundwater supplies. This assumption may be valid under the present arid conditions; however a return to wetter climates will

probably increase aquifer recharge rates which will cause water levels to rise. The geologic records indicates that springs once flowed at land surface in the Chihuahuan Desert during moister climates of the past and groundwater is now encountered only at depth where these springs once flowed. If groundwater levels in arid aquifers rise because of higher recharge rates that follow climate change, the shallow subsurface dumps may become inundated, creating a threat to surface and groundwater.

To assess water level fluctuations due to climate change, a numerical groundwater model was developed to predict and simulate the effect of wetter climates on water levels in the southeastern Hueco aquifer of the Chihuahuan Desert. Results suggest that if the recharge rate increases nearly 180% in this aquifer, the water levels may rise to land surface at some locations, inundating any waste, refuse, or contaminants above the present water table. Such an increase in aquifer recharge may be plausible, given the significant change in climate that has occurred in this area in the last 14,000 years. These issues should be considered when any waste is deposited that remains a contamination threat after several thousand years.

Climatic Impact on the Glacier Changes in Pamir-Alai Mountains during Last Decades

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Pamir-Alai is a mountain region located at the western margin of the central Asia. The western and southwestern cyclonic activity, which brings heavy precipitation to the mountain area during winter and spring seasons, developed large glaciation in this region. The Pamir-Alai plays a major role in the hydrological balance of the Aral Sea basin accumulating the great resources of snow and ice that are a source of fresh water in this area.

Inventories of the Pamir-Alai glaciers have been done in 1959 and1980 on the basis of large-scale maps and aerial photographs for the period from 1955 to 1959, and satellite images from 1978 to 1980. During twenty years the total area of glaciation decreased from 9545km^2 to 8430km^2. Changes in the glacier-covered areas caused 20% increasing of the moraine-covered areas. The glacier monitoring on several Pamir-Alai glaciers during the1990 shows that glacier-covered areas are still continuing to reduce and the contribution of glacier melt to the river runoff is decreasing respectively. To develop and validate within context of large-scale climatic trends predictive relationships linking climatic variables and glacier-covered area changes in the Pamir-Alai, the ground, remote sensing and long-term climatic data have been used. The model of glacier area changes has different plausible scenarios where the share of natural and human impact takes into account. The accuracy of this method is strongly depending on the climatic inputs that controlled by standard meteorological information from the central Asia station network.

Impact of Climate Change on River Runoff: Regional Study for the Central Asian Rivers

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All existing hypotheses of possible climate changes envisage the version about its getting warmer. Climate effect of separate regions on the global warming can be considered more or less significant. Under conditions of uneven distribution and deficit of Central Asia water resources it is very important to estimate their vulnerability to possible climate changes. The demand of water consumption which is considered to be the main factor of the stable development of the region will be increasing from year to year. According to the recent forecasting population of Central Asia will reach 90 mln. people to 2025.It will require the essential rise in agricultural production and also the industrial and everyday necessities expenses.

The effect of possible climate change impact on the rivers regime of the region can be estimated using mathematical models of runoff formation. Ones should be characterized by definite plenitude and complexity.

The applied complex of mathematical models incorporates the model of snow cover formation in the mountains, the model of transformation of rivers discharge alimentation by rain, snowmelt and glaciers. This complex allows for the computation of the main regional peculiarities of the rivers runoff formation zone which is located in the alpine regions of the Tien Shan and Pamir Alai.

Anthropogenic climate changes can be adopted as scenarios obtained with the aid of the balanced models of the general circulation of atmosphere. Thus, for example, the hardest scenarios characterizing climate aridization is given by the model of CCCM (Canada). According to this scenario rivers discharge with lower streamflow will be decreased to 40-50%. With regard to the large rivers it will be diminished to 20-30%. The unfavorable situation may be if climate change is developed by the scenario suggested by the model of UKMO (England). In this case, one can expect surface waters resources decrease by 10-20%. More favorable situation is considered in the case of GFDL and GISS (USA) scenarios realization.

Phytoremediation

Phytoremediation: An Overview

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Phytoremediation is an effective and novel approach for cleaning many waste sites, especially those containing organic chemicals at relatively shallow depths in the soil profile. Many of these wastes are not easily treated or removed by other technologies. Vegetation, such as fast growing hybrid poplar trees, can be used to metabolize, volatilize, stabilize, and/or degrade contaminants. Phytoremediation has been successful in remediating sites containing chlorinated solvents, pesticides, ammunition wastes, benzene/ toluene/ethylbenzene/xylenes (BTEX), and other petroleum hydrocarbons. Plants stimulate bacteria in the rhizosphere to degrade organic chemicals more rapidly. In addition, plants can uptake and degrade contaminants directly. Ten years of research and field applications will be discussed in the development of phytoremediation technology.

Hydrologic Effects of Cottonwood Trees on a Shallow Aquifer Containing Trichloroethylene

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In April 1996, a field demonstration was begun to evaluate hydrologic, geochemical and biologic effects of cottonwood trees planted over a trichloroethylene-contaminated shallow aquifer (< 12 feet below land surface) at the Naval Air Station, Fort Worth, Texas. Site-specific data on climate, transpiration, ground-water levels, and aquifer properties were collected or estimated to assess the hydrologic effects. Transpiration measurements were used for parameterization and validation of the hydrologic model PROSPER, which was used to simulate evapotranspiration for a 10-year period and to determine the trees' uptake of contaminated water from the saturated zone (aquifer). Simulated annual evapotranspiration from the combined unsaturated and saturated zones ranges from 28 cm (year 1) to a maximum of 48 cm (year 10); annual uptake from the saturated zone ranges from 20 to 28 cm. The ground-water flow model MODFLOW was used to simulate the effects of this estimated transpiration on ground-water flow in the aquifer. Simulated drawdown at the water table near the center of the stand of trees is approximately 15 cm for 1998; measured drawdown for the same period is approximately 12 cm. Maximum simulated drawdown at the water table (year 10 transpiration estimates) is just over 18 cm. The model results indicate that the trees are able to hydraulically influence the movement of the contaminated ground water at the site. In their current configuration, however, the trees will not be able to create a cone of depression large enough to completely hydraulically control the migration of the contaminated ground water.

Geochemical Effects of Cottonwood Trees on a Shallow Aquifer Containing Trichloroethene

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Phytoremediation uses the natural ability of plants to degrade contaminants in ground water. A field demonstration designed to remediate aerobic shallow ground water that contains trichloroethene began in April 1996 with the planting of cottonwood trees over an approximately 0.2-hectare area at the Naval Air Station, Fort Worth, Tex. Ground water was sampled in July 1997, November 1997, February 1998, and June 1998. Dissolved oxygen concentrations, which varied across the site, were near zero beneath a mature cottonwood tree (about 20-years old) 60 meters southwest of the cottonwood plantings. Chemical data of the ground water indicate that tree roots are producing anaerobic conditions in the ground water by introducing labile organic carbon that can facilitate degradation of trichloroethene by microbially mediated reductive dechlorination. Reduction of dissolved oxygen is the primary microbially mediated reaction occurring in the ground water beneath the planted trees, whereas near the mature cottonwood tree, data indicate that reductive dechlorination occurs and methanogenesis is the most probable terminal electron-accepting process. Reductive dechlorination either is not occurring or is not yet a primary process under the planted trees. On the basis of isotopic analyses of carbon-13 at locations away from the mature tree, observed trichloroethene decreases are controlled by volatilization.

Alternative Landfill Covers: A Shift from Prescriptive Design to Descriptive Process

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Current waste management practice depends on landfilling for the disposal of most municipal and some hazardous wastes. Beyond physical confinement, the primary purpose of a landfill facility is to limit the production of contaminated leachate by restricting the movement of meteoric water through the waste. Landfill covers typically utilize soil or a combination of soil and geomembranes to restrict infiltration. In addition to prescriptive cover designs, current regulations allow alternatives, given demonstrated equivalence. A lack of field-scale data hampers efforts to predict the performance of both prescriptive and alternative designs, and reflects a general uncertainty in predictions of deep infiltration in both natural and engineered systems. These uncertainties have led to the development of prescriptive cover designs that rely almost entirely on specific material parameters (i.e. the use of low-permeability soils and geomembranes) with less regard to the performance of the cover system as a whole. In contrast, alternative cover

designs often combine the water holding capacity of soil with appropriate plant communities in response to local climate regimes to return precipitation to the atmosphere. The Alternative Cover Assessment Program is constructing field-scale test plots to evaluate the performance of various cover designs throughout the country. The field effort will allow performance assessment of various cover designs in response to diverse environmental variables and will provide data for verification of numerical models.

Phytoremediation of Soil Radon

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Indoor concentrations of the radioactive gases radon (Rn-222) and thoron (Rn-220), are human health hazards. It has been estimated that decay of Ra-226 (parent of Rn-222) in soil and rocks contributes about 40% of the human population dose from all sources of radon; the indoor contribution from Rn-222 is 55%.

Previous work in this laboratory has shown that radon is readily taken up from soil into vascular plants via the transpiration stream (solubility of radon in water is the highest of the noble gases), and eventually released into the atmosphere by diffusion through the leaf cuticle independent of water transport. It was postulated that this process could be the basis of reducing radon transport into residential basements from the soil.

A series of outdoor and growth chamber experiments were carried out with soil taken from a "superfund" site contaminated with Ra-226. A computerized model was used to determine whether radon removal from soil by perennial vegetation could be predicted at a specific site using a few soil and vegetation parameters. It was also necessary to experimentally clarify some uncertainties in the process. Results of this work-in-progress are presented.

Tracking Ground Water TCE Contamination with Tree Cores

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The purpose of these investigations was to determine whether tree-core analysis could be used to delineate shallow ground-water contamination by chlorinated ethenes. At a site in South Carolina, analysis of tree cores from baldcypress [Taxodium distichum (L) Rich.], tupelo (Nyssa aquatica L.), sweetgum (Liquidambar stryaciflua L.), red oak (Quercus rubra L.), sycamore (Platanus occidentalis L.), and loblolly pine (Pinus taeda L.) growing over shallow ground water contaminated with cis 1,2-DCE and TCE showed that those compounds also were present in the trees. Baldcypress, tupelo, and loblolly

pine contained the highest concentrations of trichloroethene (TCE), with lesser amounts in nearby red oak and sweetgum. The concentrations of cis 1,2-dichloroethene (cis 1,2-DCE) and TCE in various trees appeared to reflect the configuration of the chlorinated-solvent ground-water contamination plume. Baldcypress cores collected along 18.6-meter vertical transects of the same trunks showed that TCE concentrations decline by 30 to 70 percent with trunk height. Cores collected from a variety of tree species at the Carswell Golf Course, Fort Worth, Texas, also contained (TCE) and cDCE in areas of ground-water contamination by those compounds. In some areas, TCE from ground water was detected in trees where the depth to the water table was up to 26 ft. Thus, a simple tree-coring approach can be used at these sites to inexpensively map shallow ground-water contamination.

Chernobyl Environmental Studies

Atlas of the Chernobyl Exclusion Zone

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The accident at the Chernobyl NPP caused the radionuclide contamination of land surface over large territories of Ukraine and other countries. The most intensive radioact ive contamination is concentrated in the exclusion zone and equals 110Ci, 127Ci and 800Ci for caesium-137, strontium-90 and plutonium isotopes, respectively.

The Chernobyl catastrophe attracted the attention of specialists to the problems of radioactive contamination of biotic and abiotic media and radionuclides migration through them. However, the studies being conducted are often of uncoordinated, narrow departmental character, insufficiently provided by methodology. In this connection one of the most urgent problems is to perform work on complex cartographic generalization of the results of radiological studies of the basic environment components for the most contaminated territory.

First concise issue of Chernobyl exclusion zone Atlas has been already published. When building maps for the Atlas the following basic principles were taken into account: maximal allowing for the genetic backgrounds of processes and regularities; principle of conservative evaluation, that is selection of the worst variant of data interpolation which can occur in specified ecological situation.

At present complex Atlas of Chernobyl exclusion zone is being created, which systematically describes: peculiarities of the main natural media and processes influencing radionuclides migration and redistribution; technogenous peculiarities and post-accidental transformation of the environment; radioecological and radioecohygienic situation in the zone. On the basis of analysis of these peculiarities and their involvement in the development of different inter-connected models it is planned to create the system of compatible forecasts and recommendations for effective observations and regulation of radioecological situation in the zone. The results of these studies will be included in the Atlas in the form of prediction maps. The computer-based version of Atlas is also being prepared.

Migration of Strontium 90 Within the Borschi Watershed Near Chernobyl, Ukraine

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An investigation is underway to identify the mechanisms, at the catchment scale, that control the migration of ^{90}Sr from watershed soils to surface water bodies within a small watershed 3 km south of the Chernobyl NPP. The catchment is 7 km^2 and is drained by the Borschi stream. A constructed drainage system, beaver dams, and floodgates modify

the natural water levels of the stream, and influence seasonal changes in the extent of flooded soils. Monitoring data from 1991-1998 show the ^{90}Sr flux in the Borschi stream is higher during snowmelt and storm events than during base flow conditions. Mechanisms proposed to explain higher fluxes during high flow conditions include the release of water with higher ^{90}Sr concentrations from wetlands to the stream, increased contact of surface waters with contaminated soils during runoff, and groundwater discharge of near-surface contaminated water. Migration pathways contributing to the transport of ^{90}Sr during base flow include groundwater transport to streams and leaching of ^{90}Sr from bottom sediments. The role of particulate transport on ^{90}Sr mobility in the surface water system is unresolved. Data collection includes precipitation; stream flow rates; ^{90}Sr concentrations in wetlands, streams, and groundwater; groundwater seepage into the stream channel, and ^{90}Sr concentrations in sediment samples. Our emphasis is on determining how the various transport processes are interacting at the catchment scale. The data base also provides the possibility of evaluating the feasibility of integrating physically-based surface water and groundwater transport models at the catchment scale, for a problem involving non-point source contamination.

Water Supply and Radiological Monitoring of Groundwater in Kiev Urban-Industrial Agglomeration During and After the Chernobyl Accident

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The accident at Chernobyl NPP brought to light shortcomings in organization of water supply of towns and water resources monitoring in Ukraine.

Prior to accident, among existing sources of town water supply preferences were given mainly to riverine water. Despite of rapid radioactive contamination of surface water within Dnieper basin in April-May 1986, conclusion of prevalent development of groundwater water supply was not realized in subsequent period.

Levels of groundwater 137Cs and 90Sr contamination in post-accidental period did not exceed tens-first hundreds mBq/liter. By comparison, 137Cs contamination of water in Dnieper near Kiev, as recorded on May 3, 1986, achieved 1300 Bq/liter, exceeding 35 times the then maximum allowable concentration (now this standard is one order of magnitude lower).

The Chernobyl disaster has shown that pre-accidental system of surface water and groundwater monitoring was insufficient by number of points, types and structure of observations, system of analysis and forecast of water resources quality.

Analysis of authority's activities as to water supply improvement in dangerous period during the accident and in succeeding years is given in the report. The paper also contains the characterization and forecast of groundwater quality within the Kiev urban-industrial agglomeration, studying nuclides migration pathways (involving so-called "fast migration" ones), as well as propositions on conducting radiological groundwater monitoring and requirements for water intakes.

Critical Areas in Geological Medium and their Impact on Ground Water Contamination (an Example of Exclusion Zone of CHNPP)

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The main principles of classical hydrogeology are the homogeneity of particular massifs, waterproofment of aquitards for vertical overflow and water pollutants, dominant lateral component in the formation of resource of underground waters, comes into collision with existence of pesticides, that began to employ in 70-80 years and radionuclides, which Chernobyl background are beyond of question, in the underground waters even deep aquiferous horizons that covered by powerful regional aquitard. In particular, the investigation of fast migration areas becomes important for education of contamination of the soil water horizon as the most unprotected unit of underground hydrosphere.

The closed decrease of relief (depressions, dishes, scoops) with the age (of the youngest) exceeding 40 K years can be treated as an evident example of the presence of highly active anomalous zones in the territory of exclusion zone. The consistent discharges of this region compounds 10-12 t/ha on grassed areas and near 26 t/ha on arable areas. In this case without reworking and ripple export of addition materials this forms would finish existing within 150-600 years.

From experimental works was received the data revealing that the dynamics of soil liquid phase of aeration zone and dependent on it radionuclides dynamics in anomalous zones is more and sometimes even more than background areas.

Radiohydrogeochemical Situation in the Area of Object "Shelter"

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Accident at the 4th unit of the Chernobyl NPP, happened in 1986 is the greatest technogenic catastrophe of modern civilization. As a result of explosion an active zone and all headreactor were completely destroyed. Barriers and systems of security defending an environment from radionuclides were annihilated. So, in post-accidental period exceptionally urgent became the task of creating construction to prevent environment from further radioactivity delivery. Such construction was built and received the title of object "Shelter" (OS).

Geological environment and particularly groundwater in OS area acquired a unique radiochemical composition. The main factors of this composition formation are high radioactive pollution of adjoining territory, as well as ingress of various chemical reagents used during fire extinguishing, taking measures against chain reaction appearance, deactivation, etc. Finally we cannot expel possibility of ingress to geological environment of OS highly active inter-block waters. Water activity achieves millions Bq/1 for strontium and dozens of millions Bq/1 for cesium.

In 1991 the system of radiohydrogeological monitoring wells began to be created around OS. On the basis of dosimetric and radionuclide corn analysis the pioneer determination of nuclear fuel and radionuclides distribution with geological section up to

groundwater level. Currently the radiohydrogeological monitoring wells are used for control over groundwater levels, chemical and radionuclide composition. Results of learning the radiohydrogeochemical situation within OS area are described in this paper.

Prevention of Radioisotope Migration to Ground Water in Chernobyl Exclusion Zone

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The storage of radioactive waste materials presents a major problem, as many of such products have long period of decay, and present a direct threat to human health. The only prevention from these substances is total isolation until their natural decay, which could last many years. Handling of such materials is costly and dangerous and storage must ensure that there is no access to and to avoid the possibility of leakage

The major principles of protection of aquifers from seepage of radioactive waste at Chernobyl Nuclear Power Plant by the application of STG clay-based grouting method are presented.

Proposal of the application of STG Clay-Based Grouting Method for protection of Environment at Hanford Site is presented too.

Flooding as a Trigger for Increased Radiocaesium Transfer from Organic Floodplain Soils to Cow's Milk

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During the past few years, provisional increase of Chernobyl-derived radiocaesium activity concentrations in milk of cows grazing floodplains have been observed in the months following a major flood. In the framework of the EU-funded project "Spatial and Temporal Radio-ecological Survey Systems - STRESS," this enhanced radiocaesium transfer from most peaty floodplain soils to cows' milk after flooding was investigated at a floodplain with primarily organic soils the Dubrovitsa district in north-west Ukraine. The principal aim of this survey was to better understand the hydrological and geochemical processes that governs the increased radiocaesium uptake into foodchains. Detailed topographical survey and soil and sediment sampling were carried out before and after a major summer flood that inundated the study area for about four weeks in July 1998. Three possible pathways of radiocaesium that might have caused enhanced transfer were examined, namely deposition of contaminated sediments, geochemical changes of peaty floodplain soils during flooding, and foliage uptake of radiocaesium from the river water. First preliminary results show that due to submerged peat soils, the ammonium concentration in pore water increases, enhancing the bioavailability of radiocaesium.

Deep Well Injection Disposal

An Overview of Injection Well History in the United States of America

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Injection of liquids by wells into underground formations began in the petroleum industry to increase oil production. In the 1930's it was common practice to dispose of brine by injection wells accompanied by the oil and gas production. Since the late 1940's, injection wells have been used for fluids associated with industrial facilities. Injection wells were regulated by the various states with no national oversight program.

The Safe Drinking Water Act (SDWA) was passed in 1974 to address underground injection issues from a national approach. The Act includes all types of injection wells: Class I wells which are used to inject hazardous and non-hazardous fluids below any underground sources of drinking water (USDW), Class II wells which deal with oil and gas and brine injection, Class III wells pertain to insitu mining wells, Class IV wells (now banned) handled disposal of liquids into or above USDWs, and Class V wells which relate to geothermal and other wells that do not fall into the categories listed above. The United States Environmental Protection Agency (USEPA) has implemented Underground Injection Control (UIC) rules and regulations since the early 1980's, as an outcome of the Safe Drinking Water Act, in order to protect citizen's from exposure and reduced risk to human health and the environment.

In 1984 Congress passed a continuation of the Resource Conservation Recovery Act (RCRA). This Act, in essence, banned hazardous disposal unless the demonstration was made that the injected fluid would be protective of human health and the environment. In 1988 EPA promulgated rules and regulations dealing with the land disposal ban for Class I injection wells. These regulations established a mechanism for making the demonstration of 10,000 year flow and containment of injected fluid or chemfate transformation within the injection zone.

In 1989 EPA did a qualitative/comparative risk study and found that Class I injection is a safe and effective technology due to its very low risk to human health and the environment. In this study, EPA also found underground injection of hazardous fluids was rated the lowest risk in comparison to other operations such as municipal waste combustion. Based on EPA regulations, Class I injection wells are constructed and monitored to assure protection against any toxic releases to the environment. The primary objective of deepwell disposal is to permanently isolate injected fluids from the biosphere.

A recent quantitative risk analysis agrees with EPA studies that deep well injection is a low risk management practice, less than 1 in a million. The loss of injectate isolation probability is low due to a redundancy in well construction barriers and geological requirements that provide multiple safety factors. The simple well design, with passive monitoring systems, limits the failure modes and frequencies. The regulatory requirements of a positive annulus system pressure, an auto alarm system with high reliability, and the requirements of a full time operator are very important barriers in preventing fluid migration.

Injection of Highly Toxic and Radioactive Wastes in Deep-Set Layers of the Lithosphere and Problems of the Environmental Safety

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One of the most complicated problems of the present-day human activity is liquidation of anthropogenic water wastes and especially harmful biochemical and radioactive fluids.

Within the vast range of widely used technologies the most commonly accepted is wastes injection into deep-set parts of the lithosphere.

Though very attractive from the economic point of view and seeming reliable enough, this method bears in the hidden form a threat for survival itself of a Man. This danger being taken by planners and decision makers as a remote one is underestimated.

The results of the recent 20-year investigations of the HydroGeoDeformation (HGD) field of the Earth show that in the lithosphere there is the globally spread and permanently functioning process of properties changes of rocks both permeable and impermeable ones. For this reason aquitards at certain phases of the HGD evolution loose their screening ability and become permeable (the so-called "effect of shifting sieve").

At the background of vertical/horizontal discharge of ascending thermal fluids (being controlled by the processes of geodynamic filtration), injection of toxic and radioactive wastes can produce the most hazardous harm for huge regions.

The strongest necessity does exist to look for alternative solutions that would not disturb equlibria formed in the hydrosphere.

Modeling of Deep Injection Disposal of Liquid Radioactive Wastes on Russia

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Deep injection disposal of liquid radioactive wastes has been used extensively in Russia. Since 1963, more than 40 million m^3 of wastes, with a current activity of about 0.8 billion Curies (Ci), have been disposed in reservoir horizons in the regions of Tomsk, Krasnoyarsk, and Dimitrovgrad. Geologic and modeling investigations were conducted to determine the preliminary suitability (or unfitness) of the selected disposal sites selected before injection activities were authorized and initiated (Rybal'chenko et al. 1994, 1996; Foley and Ballou, eds. 1998). These investigations were used to evaluate the feasibility and safety of deep injection disposal, to assess its impact on the environment, and to design the injection sites. Different models of the geological medium and hydrogeological conditions were used, and calculations were made to predict the change from undisturbed conditions of the injection and surrounding geologic horizons that would be caused by disposal activities, migration of waste components, and heating of the rocks by the wastes.

Development of Flow and Transport Models of Liquid Radioactive Waste Injection Using Data from Siberian Chemical Plant Injection Site

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The major focus of our investigation was simulating pre-injection and post-injection subsurface conditions at the waste disposal site of liquid radioactive wastes generated at the Siberian Chemical Plant located near the city of Tomsk. The main environmental and human safety concern posed by this site is related to the potential radionuclide discharge into the Tom River (zone of regional ground water discharge) and into the existing public water supply wells located 8 to 10 km away from the site. Even though the site's two lower injection aquifers are isolated from the upper aquifers by a relatively continuos aquitard, in terms of regional flow, they represent one hydrogeologic system that is affected by injection, ground water withdrawal from the upper aquifers, and ground water discharge into the river.

A number of ground-water flow and transport models were developed to simulate flow and transport at the different scales and to incorporate different physical processes and conceptual assumptions about the system modeled. As a result, two regional models of the overall ground water system were developed to simulate the migration of the non-reactive conservative contaminates over the time period from the beginning of injection to the present. The differences between these models were in conceptual assumptions that in case of the first (pre-injection) model were derived from the pre-injection site characterization data and in the case of the second (post-injection) model were derived from all site characterization and monitoring data collected up to date.

Both models yielded similar predictions concerning the current location of the contaminant plume and corresponded with observations. In other words, the short-term prediction provided by the model based on limited data was as acceptable as the prediction provided by the model based on the most complete information. However, the obtained results were different when these models were used to simulate contaminant transport over 1,000 years. The post-injection model indicated a potential for the upward movement of some amounts of contaminants through the lithological windows in the clay aquitard that were not detected prior to the beginning of the injection. Analysis of geophysical and drilling data shows that the probability of existing lithological windows in the aquitard is not zero. Thus, the conceptual post-injection model incorporates heterogeneity of the clay aquitard with possibility of preferable flow via windows. Simulation conditioned on lithological data is used for modeling the clay aquitard heterogeneity in the post-injection model. According to the data used to develop the pre-injection model, this clay layer was assumed to be continuous over the entire region. Therefore, we can conclude that the methods used and the data collected during the site characterization phase in the beginning of 60th were adequate for determining ground water flow and contaminant transport parameters, but not sufficient to encompass all the possible conceptual models of the site.

None of the simulations indicated that, even over 1,000 years, there is any serious potential of contaminating existing water supply wells and recharge zone. Consequently,

future work should tie up these modeling results with the calculations of risk associated with the overall plume migration, especially with contaminate migration through the clay aquitard. Such a study would determine the relative importance of lithological windows and therefore, the relative importance of site characterization in proving or disproving basic modeling assumptions. Additional field characterization of the aquitard properties should be performed in the vicinity of the existing water supply wells and along the potential contaminant migration pathways that lead to the ground water discharge zone.

Prediction of Contaminant Plume Movement from the Deep-Well Injection of Liquid Radioactive Waste (LRW) at the Krasnoyarsk Disposal Site

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The principal goal of the LRW deep-well injection is its long-term isolation from the ecosphere. In the paper, the results of predictive simulation of radionuclide migration from the deep-well injection zone at "Severny" disposal facility of the "Mining and Chemical Combine" (MCC) in the Krasnoyarsk district are presented.

The studies performed include:

1. Conceptual analysis of the injection site geological and hydrogeological conditions injection zone.
2. Evaluation of the impact of the different driving forces on contaminants transport.
3. Solution of calibration problem for hydrological properties distribution in Aquifer I which hosts the intermediate-level LRW.
4. Simulation of contaminants migration in Aquifer I taking into account the hydrodynamic interaction with Aquifer II which contains the low-level LRW.
5. Solution of calibration problem for hydrological properties distribution in Aquifer II.
6. Simulation of contaminant migration in Aquifer II.
7. Sensitivity analysis of the potential impact of uncertainty in hydrological properties distribution on contaminant migration in Aquifer I.

The results of these studies indicate that for the normal evolution scenario, the potentially most hazardous LRW disposed of in Aquifer I are reliably isolated from the ecosphere for a period of no less than 1,000 years.

Verification of Flow and Transport Models of Liquid Radioactive Waste Injection Using Monitoring Data of Site Injection

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Deep well injection of liquid nuclear wastes at the Mining Chemical Combine in the Krasnoyarsk region has been began in 1967. Network of observation wells at the deep well injection site collected data of monitoring hydraulic heads and underground waste spreading. In present work these data are used for verification of a conceptual model of underground waste spreading. For this purpose flow and transport model was developed and numerical modeling reproduced history of the injection was performed. After calibration process the results of modeling are compared with the monitoring data. The results of this comparison are discussed in presentation. In general, the comparison shows quite good agreement of numerical and observed breakthrough curves in observation points and general agreement of observed and modeled plumes locations. It gives additional support to the used conceptual model of injected waste spreading.

Correlation between Lateral and Vertical Migration of Radionuclides

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Studies of radionuclides transfer from the upper soil layer were performed in Chernobyl zone. Correlations between the main ways of radionuclide migration were analyzed: erosion transfer with temporary aqueous floods; vertical migration within the soil layer and fast migration to great depth. Parallel with studying of natural radionuclide migration, annual experimental cycle as to intensive artificial sprinkling of run-off plots was accomplished. Equipment provided to allow for radionuclides mass and activity of fluid and solid run-off both in natural wetting regime and during experimental sprinkling. Except leaming of radionuclides erosion transfer on experimental plots it was investigated their vertical distribution with soil depth (approximately till 1 m) and along cross-section up to the groundwater level. It was established that erosion lateral transfer of radionuclides by surface run-off composing the tenth shares of percent from its reserve in the soil layer, is least considerable. Vertical radionuclides migration in the soil layer was estimated in a few per cent. Important factor of radionuclides migration is their abyssal penetration in geological environment. Substantial thickness of geological section even in low radionuclides activity gives values in units (for polluted territories) and dozens of per cent (for comparatively clean territories) from the initial surface pollution. Zones of quick migration in geological environment play a particular role in abyssal radionuclides penetration. Occupying small area, they, owing to their raised filtration properties, enter a great contribution in radionuclides penetration through aeration zone to groundwater. The results of research are presented in this paper.

Protective Properties of the Vadose Zone Rocks Relative to Radioactive Contamination Dispersion

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The vadose zone is the upper part of the crust of the Earth and it is widespread. The main feature of the vadose zone is low water-saturation of its rocks. Lithologically, it is

chiefly sandy-argillaceous formations, which are characterised by heterogeneous composition and properties as a rule.

As analysis of origin and dispersion of radioactive contamination (accidents, leaks etc) shows radionuclides penetrate primarily into the rocks of the vadose zone and then into water-table streams. It is confirmed by the Chernobyl experience and many other events of radioactive contaminations taking place throughout the world. In this connection it is very important to evaluate protective properties of rocks of the vadose zone.

Long-term observations concerning radionuclides migration under natural conditions have been conducted to evaluate protective properties of rocks of the vadose zone. 90-Sr solution with comple son added was used as the contaminant source. Field-scale experimental study was conducted for observation of contaminants plume formation in the vadose zone resulted from introduction of 90-Sr solution into simulated crib (2m x 2m and 2m deep) with impermeable walls and filtrating bottom. Water was poured into the crib prior to introduction of contaminants to achieve a steady-state drainage rate. 73,5 cu m of solution were introduced with average concentration of 1.10^{-5} Ci/l.

Geologically the vadose zone has a complex structure resulting from its glacio-fluvial origin. Inclusions of clays, loams and silts in the sandy layers result in an environment with a sharp vertical heterogeneity in transmissivity properties.

After introduction of 90-Sr solution wells were drilled around the crib and core samples obtained. Then over the next 8 years the observations were performed in four stages to study 90-Sr migration and moisture dynamics at the test site. Simultaneously laboratory studies of the core samples were undertaken to investigate the sorption capacity of the vadose zone sediments for other radionuclides (137-Cs, 60-Co, Ru, etc).

This work yielded a large amount of data describing the migration of 90-Sr in saturated medium within the vadose zone under natural conditions. Empirical dependencies were established between the speed of 90-Sr migration and the process time and different concentration values. Dependencies were established for plume formation as determined by the properties of the geological environment. Balance calculations made for 90-Sr at every observation stage provide a high degree of coincidence, which validated the experimental procedures.

The results obtained allowed to evaluate a number of plumes in the vadose zone and ground waters and develop measures for rehabilitation of the radioactive contamination areas.

Nuclear Waste Disposal and Isolation

Suggestions for High Level Nuclear Waste Management Approach in Russia

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The substantial amount of spent nuclear fuel (SF) accumulated by now in Russia is stored at the local and centralized facilities. The concept of the postponed closed nuclear fuel cycle that is currently being developed in Russia considers the possibility of the long-term storage of the SF what will provide the necessary time for development of the advanced SF management technologies.

Russia has also a large amount of the different types of radioactive wastes (RW) including liquid, solid and solidified high-level nuclear waste (HLW). In the HLW management concept subdivision of the HLW stream into fractions of the long-lived and intermediate-lived radionuclides is considered. Such a separation of the HLW stream opens the perspective for development of the different approaches to subsequent treatment of the different HLW fractions. There is already a sufficient scientific basis for ensuring reliable isolation from the environment of intermediate-lived radionuclides for the whole period that is necessary for their practically entire decay. Such isolation could be achieved through construction of regional disposal facilities located not far off the waste producing nuclear enterprises. For isolation of long-lived radionuclides, a centralized national disposal facility should be constructed within the stable geological block. However, this could be realized only after solving all scientific problems caused by the necessity of the extra-long-term isolation of the long-lived HLW from the environment.

In site selection for HLW geological disposal the conventional multi-barrier strategy should be supplemented by the more sophisticated analysis of hydrogeological conditions providing groundwater long-term travel times from the disposal zone to the biosphere.

The Use of Numerical Models to Evaluate the Performance of Nuclear Waste Repositories

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Numerical models are essential for the reliable design and analysis of tests conducted to characterize potential geological sites for high-level nuclear waste repositories. In general, the geological formations being considered for potential repositories of nuclear waste are highly complex and heterogeneous. In addition, there are many processes that need to be considered; these include important hydrological, geochemical, thermal, and mechanical processes. In many cases, there is strong coupling between those processes requiring simultaneous solutions of different equations that must be done numerically. Today, there are several sophisticated three-dimensional multi-continua, numerical simulators that can address a wide variety of complex problems involving coupled processes.

At Yucca Mountain, Nevada, the potential site for the U.S. high-level nuclear waste repository, numerical models have been used extensively in conjunction with laboratory

and field measurements, to characterize the site and to evaluate its potential for safe isolation of radionuclides. Large-scale (100,000 gridblocks) numerical models have been developed and calibrated against all available data from both the deep unsaturated zone above the water table, and saturated portions of the system. These models were calibrated against various data sets including pneumatic, saturation, moisture tension, temperature, geochemical, and perched water data. In addition, the models have been used to predict the expected behavior of future tests and measurements. The experience so far shows that the models are converging to yield increasing reliable predictions of important hydrological, geochemical, and thermal processes at various spatial and temporal scales. This experience helps us to gain confidence in the models for their predictions of radionuclide transport over long time periods.

This paper describes the various models used to characterize and predict flow and transport in the unsaturated zone at Yucca Mountain. The experience given with these modeling studies of Yucca Mountain over the last decade is described in terms of their applicability to other potential nuclear waste repositories.

Groundwater Flow and Transport Modeling for Yucca Mountain Site

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Yucca Mountain, located in southern Nevada on the southern boundary of the Nevada Test Site (NTS), is being evaluated for the construction of a nuclear waste repository that would be100 to 200 meters above the water table in a thick unsaturated zone. Because release of radionuclides to the environment is expected to occur through dissolution and transport of the waste by ground water, a comprehensive model of groundwater flow and radionuclide transport at and downgradient from the site area is necessary. Dilution of a contaminant plume emanating from the repository will depend in part on the natural mixing in the upper part of the saturated zone. A low ground-water-flow velocity would allow decay of radionuclides in the plume before release to the accessible environment. An accurate representation of ground-water-flow paths, travel times, and transport processes in the saturated zone is important for estimating where the contaminant plume may discharge at land surface or be intercepted by wells in the future. A three-dimensional, finite element, saturated zone groundwater flow and transport model is being constructed to simulate radionuclide transport from Yucca Mountain to a compliance point 20 kilometers downgradient from the potential repository. The model uses the finite element code, FHEMN, and particle tracking techniques are used to solve for the advection process. Trajectory and travel times of particles are computed within a cell by velocity interpolation. Dispersion is modeled with a random-walk algorithm. Matrix diffusion and sorption are modeled using a transfer function approach. The flow component is being calibrated through the use of water level data from 90 wells, the results of long term hydraulic testing, and geochemical interpretations.

Integration of Geodynamical and Hydrogeological Models for Selection of Perspective Areas for Isolation of Radioactive Wastes in Geological Formations

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A complex geodynamical and hydrogeological model was created to solve the problems of revealing geological structures and parts of crystalline rocks in Pro-Cambrian basement within the Chernobyl exclusion zone and north-eastern part of Korostensky pluton, which are perspective sites for radioactive wastes (RAW) isolation.

The algorithms were developed to transform the earth's surface into a complex set of parameters, characterizing heterogeneity and dynamics of the stressedly deformed state of the earth's crust. The computer-based treatment of geological and geophysical data was performed. A transformation scheme for the first- and second-order derivatives of gravitational and magnetic fields, as well as a gradient scheme for fields of vertical and lateral stress anisotropy, were also obtained.

The created structural-tectonic scheme depicts the basic systems of ruptural dislocations, their kinematics and morphology. The basic tectonic structures were revealed, and the time consistency of their activation and a real occurrence of relative structural-substantial and tectonic processes were determined. A nine-layer hydrogeological model was developed involving the sedimentary sheeting and crystalline basement of the territory under study. The main characteristics were determined which stipulated the favorable hydrogeological conditions for depth RAW isolation. On the basis of structural-geodynamical and hydrogeological zoning to a scale of 1:200,000, the parts of crystalline basement most appropriate for further investigations were separated at the depth 500-1000m.

Infiltration Relations for Yucca Mountain Future Climates Based on Surface Hydrology Approaches

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Percolation is a key issue for the Yucca Mountain Project, and infiltration helps determine that percolation. Estimates for infiltration, based on changed climate, indicate a large increase in infiltration under those wetter climate conditions postulated for the future. This paper, which looks at infiltration from the standpoint of identifying and interpreting fundamental flow characteristics in soil and rock, concludes that these large increases are unrealistic.

In hydrologic studies of basins, infiltration estimates have found that infiltration rates equal supply rate when supply is less than infiltration capacity, and are equal to infiltration capacity (an exponential function of the time from the beginning of rainfall) when supply rate exceeds infiltration capacity.

Because most infiltration studies include or are dominated by soil materials, the concepts may not be entirely applicable to fractured rock. Assessment is made of the

functional relation expected for fracture flow, based on open-channel flow approaches. The quantity of water that can flow down a fracture is a function of the wetted perimeter and depth of flow. Assuming that the wetted perimeter does not change, the flow would be entirely a function of the depth of flow within the fracture. Until the fracture is filled, the flow in the fracture would increase as a function of the cube of the depth. Once the fracture is filled, friction losses decrease the flow because the wetted perimeter increases significantly.

Thus, in fractured rock, the infiltration rate would be a linear relation wherein infiltration increases in direct proportion to the supply rate until the supply rate equals or exceeds the infiltration capacity, reached when fractures become entirely filled with infiltrating water. Once fractures are filled, capacity becomes constant as long as frictional losses are constant.

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Engineered Barrier Testing for the Yucca Mountain Project

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The Yucca Mountain Project is currently developing a License Application (LA) design for the underground facilities in the potential repository. A subset of this LA design is the emplacement drifts and the engineered barrier system components within them. The intent of the engineered barriers is to enhance repository performance by diverting water flow away from the waste package. Configurations being evaluated include a sloped capillary barrier (fine sand) over a coarse-sand backfill and a simple coarse-sand backfill. Initial tests were conducted at ambient temperatures.

The work described here details the initial pilot-scale experiments (1.4m diameter by 4m), which are approximately drift scale. We employ physical experiments coupled with numerical modeling to directly evaluate the performance of engineered barrier system alternative designs under a range of infiltration scenarios. Physical experiments involve both two- and three-dimensional test systems. The two-dimensional tests are designed to allow full visualization of the fluid flow paths within the backfill system (1.4 m diameter by 2.5 cm thick with Plexiglas face plates) while the three-dimensional test are designed to capture the full dimensionality of the test problem. Pretest modeling predictions of the pilot-scale tests and pilot-scale flow visualization testing are also described. Experiments involve placing materials loosely around simulated waste packages, applying constant line source infiltration flux along the top of the experiment, and monitoring water movement with installed instrumentation and observations. Water contacting the simulated waste package is observed using a visual and UV camera system within the simulated waste package. The water balance of the system is measured by comparing injection, storage, and effluent weights. Discharge of water from the test system occurs through a series of engineered wicks, designed to simulate the natural fracture network, and by gravity drainage from the bottom the test cell.

Results show that for the injection rates applied and materials, the capillary barrier diverts a significant amount of all injected water. These results are consistent with the pretest predictions. The standard backfill, although practical, allows the injected water

to contact the waste package. Water balance measurements account for nearly 99% of the applied water.

The Role of Capillary Barriers in Reducing Moisture Content on Waste Packages

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Assessment of the performance of engineered capillary barriers at the potential Yucca Mountain nuclear waste repository site, in which 1.67-m-diameter waste packages are to be emplaced in 5-m-diameter tunnels according to current design, brings up aspects not commonly considered in more typical applications of capillary barriers (e.g., near-surface landfills). Engineered capillary barriers typically consist of two layers of granular materials with a sloping interface, in which the contrast in capillarity between the layers keeps infiltrating water in the upper layer. One issue is the effect of thermohydrologic processes that would occur at elevated repository temperatures (and temperature gradients). For example, backfill materials may be altered from that of the as-placed material by the hydrothermal regime imposed by the emplacement of waste in the repository, changing hydrologic properties in a way that degrades the performance of the barrier. A reduction of permeability in the upper layer might diminish the capacity of the upper layer to divert incoming seepage or to cause a "vapor lid" whereby buoyant vapor flow would be trapped, then condense and drain onto waste packages. Other concerns are the result of highly spatially and temporally variable seepage distribution and the very limited spatial scale available for flow attenuation and diversion.

Evaluation of a Capillary Barrier Backfill System for Yucca Mountain

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A capillary barrier backfill system is currently being studied for the potential high level waste repository at Yucca Mountain to divert incoming infiltration from the waste packages. The capillary barrier studied consisted of poured coarse and fine materials so the natural dip of the layers will be the angle of repose for the materials. Locally available inexpensive materials are being considered for the fine and coarse layers. Pilot-scale experiments are being conducted to directly evaluate the performance of the capillary backfill system.

The geometry and application of this capillary barrier system, which is different than a typical landfill capillary barrier, presents unique challenges in the design. For example, the length of the capillary barrier in the pilot-scale tests is only about 0.8 m long, which terminates at the test section wall, and the angle of repose is approximately 30 degrees.

For this limited length, the wall boundary condition is of utmost importance. Wicks have been added to the wall to drain away the water in the fine and coarse layers, with suction conditions similar to what is expected in the potential repository. This wall boundary condition significantly influences the calculated performance of the capillary barrier system.

In addition to the geometrical challenges, the imposed infiltration condition is different. Typical capillary barrier analysis and modeling usually considers infiltration due to precipitation such that the infiltration rate is relatively uniform spatially across the top of the capillary barrier. In the present Yucca Mountain application, the infiltration is assumed to come from a single fracture located at the top of the fine layer. Thus, the infiltration is a point source rather than a spatially uniform source. Therefore, immediate failure of the capillary barrier at the point of infiltration is possible if the rate is high enough.

Evaluation of the capillary barrier conditions has been performed with the TOUGH2 code for unsaturated flow in porous media. Calculations show the dominance of the wall boundary condition on the capillary barrier behavior, especially in the fine layer.

Using Engineering Design to Control the Influence of Thermal Processes on the Hydrologic System around an Underground Nuclear Waste Repository

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Depending on the repository design, heat from the decay of radioactive waste can have a dominant influence on the hydrologic system that develops around the repository, effecting critical system performance variables such as temperature, relative humidity, and seepage flux on waste packages, as well as the chemistry of the seepage flux. The combination of two characteristics of the potential high-level nuclear waste repository being considered at Yucca Mountain, a vadose zone location and waste packages with a relatively high heat-generation rate, allows thermal management to be utilized as a design tool to optimize repository performance. We have recently performed thermohydrologic-model calculations of alternative designs for the potential repository at Yucca Mountain. These designs cover a wide range of heat-driven behavior. In some, temperatures permanently remain sub-boiling throughout the repository. In others, the boiling zone can extend more than 200 m from the repository and last up to 10,000 years. A combination of end-to-end waste package spacing in widely spaced drifts, ventilation, and backfilling the drifts results in a design which promotes better drainage pathways around drifts, reduced likelihood of moisture contact on waste packages, and lower drift and rock temperatures, relative to alternative designs. End-to-end waste package spacing results in more locally intensive and uniform heating along drifts, causing hotter, drier, and more uniform conditions on waste packages than wider package-to-package spacing, which was used in earlier project designs. Backfilling drifts with a granular material with

coarse, well-sorted, nonporous grains (e.g., a coarse quartz sand) results in a large, persistent reduction in relative humidity on waste packages.

Mayak Environmental Studies

Current State of Ground Water Contamination at the Mayak Site

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The origin of groundwater contamination at the Mayak site are leakages from reservoirs, which have been used for liquid radioactive wastes storage, namely, Lake Karachai, Staroye Boloto (Old Swamp), and Reservoirs of Techa Cascade, especially Lake 11. They have close interconnection with groundwater and each of them can be considered as a permanent source of contaminants. The spatial and temporal regularities of the contaminant plumes evolution have been studied. The contaminant plume behavior is governed by the geologic structure of the area under investigation, hydraulic properties of water-bearing rocks, and the content of migrating solution. This report will include the following information about the current contamination of groundwater:

- brief description of reservoirs and the existing plumes of contaminants,
- description of groundwater monitoring system and monitoring procedure,
- results of joint Russian-American field studies performed under the Site Characterization & Contaminant Transport program of Joint Coordinating Committee on Environmental Restoration and Waste Management (JCCEM), the managing body of a Memorandum of Cooperation between DOE/EM-50 and the Ministry of Atomic Energy for the Russian Federation.

Riverine Pollution at Spent Fuel Reprocessing Sites in Russia: Mayak, Krasnoyarsk-26 and Tomsk-7*

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During the Cold War, production and testing of nuclear weapons in the United States and the Soviet Union led to major releases of radioactive materials to the environment. Although major studies have begun to clarify the magnitude and impact of releases in the United States, only since Perestroika has information become available to begin to evaluate the significance of releases to the environment in the Former Soviet Union. The International Institute for Applied Systems Analysis in its Radiation Safety of the Biosphere Project has been studying the impact of radioactive discharges to the Techa River at the Mayak Production Association (Cheliabinsk-65)(Ozersk), Yenisey River at Krasnoyarsk-26 (Mining and Chemical Combine) (Zheleznogorsk) and the Tom River at Tomsk-7 (Siberian Mining Combine) (Seversk). The studies were done in collaboration with institutes of Minatom and the Russian Academy of Sciences and the Kurchatov Institute as well as with the site and local administrative authorities. The studies analyzed the impacts to the downstream inhabitants of past discharges of the radioactive materials

to their respective rivers with normal evolution of events and under abnormal evolution. All of the studies were done with limited data. provided by Russian participants of IIASA project. Generic models with site specific data were used, though some new models were developed for these studies.

The first study was at the most famous radioactively contaminated site in the FSU, other than the Chernobyl and Kyshtym accidents. The study of the Techa River provided insight into the potential for further radioactive exposure problems at the site due to continuous and accidental releases from the Techa River Cascades and the associated hydrologic systems. Continued institutional controls on the use of the Techa River and the need to reduce the potential for accidental releases from the Cascades were emphasized. The next studies evaluated current radiological impacts of releases of radionuclides to surface waters at the two gigantic Siberian nuclear complexes, Krasnoyarsk-26 and Tomsk-7. Possible changes of this impact due to the redistribution of existing contamination by flooding through river systems of the Tom and Enisey were studied. Modeling of the redistribution covers 300 km, along the Enisey River and the stretch of the Tom River between the estuary of the Romashka River that passes through the Tomsk-7 site, and the Tom's confluence with the Ob River. Though it was expected that the impacts would be similar to those at the Techa River, this was not the case. Though the radioactive releases to the rivers were large, they were mostly of shorter half-lived isotopes and were swept downstream in the river and mostly decayed on route. However, the potential for high doses resulting from accidental releases from radioactive wastes stored on the surface must be taken into account.

Contaminant Transport Modeling in the West Siberian Basin

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Nuclear fuel cycle activities of the Former Soviet Union (FSU) have resulted in significant contamination of the environment in western Siberia. The U. S. Department of Energy's (DOE's) Pacific Northwest National Laboratory (PNNL) is developing, jointly with their Russian counterparts in the Ministry of Atomic Energy of the Russian Federation (MINATOM), multi-scale, three-dimensional (3-D) models of the hydrogeology and potential contaminant migration in the West Siberian Basin. These models and modeling strategy will be validated using decades of data from measured contaminant migration at the Mayak, Seversk (Tomsk-7), and Zhleznogorsk (Krasnoyarsk-26) sites. This project is being conducted under the auspices of the Joint Coordinating Committee for Environmental Remediation and Waste Management (JCCEM). The long-term goal of this work is to test and build confidence in the capability of DOE's contaminant transport models to predict future environmental and human impacts of radioactive contaminant releases at DOE sites. Our joint objectives are to develop semi-automated approaches integrating site characterization, conceptual modeling, and numerical modeling for radioactive contaminant transport and validate them in multi-scale, 3-D, transient contaminant transport models for the Mayak and Seversk regions. This proven technology will then be transferred for use at DOE sites. DOE uses such models to evaluate the potential for risk from contaminated U. S. sites, and will benefit both from model validation and from technologies transferred from

Russian site remediation work. Pacific Northwest National Laboratory is operated by Battelle Memorial Institute for the U.S. Department of Energy under Contract DE-AC06-76RLO 1830. This work is funded by the Office of Science and Technology, within the Department of Energy's Office of Environmental Management, under the Characterization, Monitoring, and Sensor Technology Program.

Development and Calibration of a Three-Dimensional Regional Hydrogeologic Model of the Mayak Site, Urals

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This paper discusses a hydrogeologic model being developed and calibrated through a joint Russian and U.S. study to quantify the hydrogeology of the Mayak territory, located near the town of Kyshtym in the southern Urals. Nuclear fuel cycle activities at the Mayak Site resulted in the contamination of soils and groundwater with chemical and radioactive wastes. In one example, about 4 million m^3 of high-density liquid wastes (~ 60 g/L TDS) were discharged from Lake Karachai to the groundwater from 1951 to 1991. A three-dimensional hydrogeologic model of the Mayak territory is being developed to investigate groundwater flow and contaminant transport to help address waste management issues and for subsequent use in forecasting and evaluating environmental restoration measures.

Experience of Contaminant Transport Forecasting at the Mayak Site (GEON-3D Model)

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The numerical models of the contaminant transport in groundwater have been developed since 1990 by a group of experts from several institutions. The work has been implemented in two directions. One of these directions includes collation of necessary input data to develop a conceptual model taking into account main assumptions and limitations. The second one is to develop software for modeling. All computer codes have been developed taking into account geologic and hydrogeologic features of the "Mayak" site. This report will contain the description of the modeling efforts, including:

- several stages of GEON~3D model development and with the use of different

conceptual models improved;
- model software modifications;
- experience of forecast calculations;
- uncertainties of the model and prospects.

Construction of a Recharge Model for Transient Groundwater Flow and Contaminant Transport at the Mayak Site

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Groundwater flow and contaminant transport models require estimates of recharge to drive the regional water balance. In the absence of direct measurements of recharge using lysimeters or tensiometer-piezometer arrays, the most commonly applied methods for recharge estimation are moisture balance methods and Darcian approaches. An application using both approaches is necessary to estimate recharge for the Mayak Site regional transient groundwater flow and contaminant transport model because surpluses or shortages of recharge affect the water table configuration non-uniformly one year later. A moisture balance was applied to determine the amount and spatial distribution of surplus water for any given year. Application of the method using monthly average precipitation and temperature data, an assumed vegetation distribution, and land use characterized from SPOT imagery indicated no water surplus, despite the fact that recharge undoubtedly occurs in the area. The lack of indicated surplus was due to the use of monthly average measurements for precipitation and temperature, since recharge-yielding precipitation probably occurred over the course of only a few days. To avoid having to use daily precipitation and temperature data to estimate recharge for the 50-year period of model simulation, we used daily records to calculate the water balance for representative months when recharge was probably occurring (spring) and when recharge was unlikely to be occurring (summer and winter) and linked these to monthly averages using patterned regressions. The results indicate that most water surpluses occurred during early spring, when snowmelt was at a maximum and evapotranspiration at a minimum, in agricultural areas bare of crops. These surpluses were then routed through the unsaturated zone using Darcian approaches and calibrated to the water table configurations for wet, dry, and normal water years.

Study of the Industrial Solutions and Interaction with Water-Bearing Rocks in the Process of Contaminant Transport

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The study of physical-chemical interactions of industrial solutions and water-bearing rocks has been conducted for a long time by laboratory tests of unconsolidated sediments

and cores of fractured rocks. The process of ^{90}Sr sorption by unconsolidated sediments has a better understanding: The K_ds for different types of the sediments were defined on the basis of numerous laboratory analyses. The radionuclide retardation in fractured medium was characterized using long-term monitoring data for radionuclides and neutral components. Model simulations of ^{90}Sr transport for a fragment of groundwater flow in the vicinity of the Lake Karachai allow us to assess the radionuclide retardation by fractured rocks. A number of studies were conducted within the framework of the Site Characterization & Contaminant Transport focus area of the Joint Coordinating Committee on Environmental Restoration and Waste Management (JCCEM), the managing body of a Memorandum of Cooperation between DOE/EM-50 and the Ministry of Atomic Energy for the Russian Federation.

The following information will be presented in this report:

- description of the main factors of contaminant transport;
- laboratory K_ds for different types of unconsolidated sediments;
- results of joint Russian-American field studies aimed to determine the in situ sorption properties of sediments in the river valley;
- results of comprehensive laboratory studies of the cores of fractured rocks to assess radionuclides retardation;
- results of ^{90}Sr transport modeling.

The Chemical Interactions between a Migrating Plume of Liquid Radioactive Waste and Weathered Bedrocks in the Vicinity of Lake Karachai, near Chelyabinsk, Russia

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During the Cold War, a large quantity of intermediate level liquid radioactive waste from radiochemical processing facilities near Chelyabinsk in the Southern Urals was discharged into the adjacent Lake Karachai. The contaminated lake water, initially containing a strong $NaNO_3$ brine and 120 MCi of fission product radionuclides, has been draining from the lake and migrating downstream through the shallow subsurface environment in both southerly and northerly directions. The resulting plume now covers 15 km^2 and extends nearly 3 km south of the lake. Its chemical evolution in that direction has been extensively investigated over a number of years by means of monitoring wells. Hydrogeochemical logging and chemical analyses of well waters reveal a complex array of chemical interactions. These include radiation induced oxidation of CH_3COO^- and $C_2O_4^{2-}$ to HCO_3^- and CO_2, decomposition of NO_3^- to NO_2^- and NH_4^+ and release of O_2, ion exchange of Na^+ for Ca^{2+}, Mg^{2+} and Sr^{2+}, and supersaturation and precipitation of Ca-Mg carbonates with co-precipitation of ^{90}Sr. A geochemical evaluation of the data permits a self-consistent explanation of the observed chemistry and prediction of total system behavior including the fate of radionuclides in the plume. Eh measurements are

consistent with redox equilibrium between nitrogen bearing species, and pH, HCO_3^- and CO_2 gas pressure is consistent with the venting of excess CO_2 gas at atmospheric pressure. Plume waters are, however, supersaturated with respect to calcite. It is not clear whether calcite precipitation is inhibited by the precipitation of metastable microcrystalline or amorphous carbonates.

Mechanism of Strontium Sorption from Contaminated Ground Water Leaking from the Karachay Lake

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The experimental study of sorption of the strontium by the PA Mayak area soils from sodium nitrate solutions of different concentrations has been carried out. The objective of the study is to evaluate the parameters needed for computer modeling of the strontium behavior in water discharging from the Karachay Lake into the ground water. In particular, we have investigated dependence of the Sr^{90} sorption on dilution of the sodium nitrate solution with ground water. The distribution coefficients ($K_D = C_{solid}/C_{solution}$) of different soils have been measured for the NO_3^- concentrations of 20, 6, 2 g/L, and for the zero-concentration ground water (K_{Do}). It has been found that the sorption abilities of soils vary within a wide range, but for every soil K_D increases with the decrease of the sodium nitrate content.

Three different thermodynamic models have been examined to describe the experimental data on sorption: 1) ion exchange Sr^{2+} - Na^+; 2) ion exchange Sr^{2+} - Na^+ coupled with the Sr^{2+} – NO_3^- complex formation in aqueous solutions; 3) ion exchanges both Sr^{2+} - Na^+ and $SrNO_3^+$ - Na^+. It has been shown that the last model provides considerably better approximation of experimental data. Constants $K_{Sr2+,Na+}$ and $K_{SrNO3+,Na+}$ of the ion exchange sorption have been evaluated for various soils.

A general equation expressing K_D of soils in terms of sodium nitrate concentration and K_{Do} has been derived on the base of this model.

Modeling and Experimental Studies of the Lake Karachai Site Problems

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The presentation addresses modeling analysis of the major hydrodynamic and hydrogeochemical mechanisms governing subsurface radionuclides transport at the Lake Karachai Site. Among these mechanisms are: 3D density induced advection, macrodispertion, large storage capacity of the lower aquatard, and physical-and-chemical interactions in a multicomponent system.

To study solute transport process, a set of numerical models have been developed and mutually tested. The model construction was based on different physical approaches and numerical schemes. Computer codes developed earlier by other authors (HST3D, TOUGH2, METROPOL-3, CODESA-3D) were involved in the testing procedure as well. Results obtained with the aid of simplified models (DensElow), assuming sharp-interface between brines and fresh water, showed that the artificial (numerical) dispersion taking place in finite-difference and finite-element models can lead to noticeable errors in identification of the subsurface plume spreading characteristics.

The hydrogeochemical processes were studied with help of: (a) computer simulation of geochemical equilibrium reactions and (b) laboratory modeling of the sorption interactions. It was found that sorption of some radionuclides is partially irreversible. The role of the latter as well as desorption kinetics in the site's natural remediation was investigated by means of simplified analytical and numerical models. On the whole, the natural attenuation approach could be considered as the most real and efficient ground water environmental strategy for this particular site.

Long-Term Prediction of the Alteration of Water-Balance Elements in the Techa Cascade of Radioactive Industrial Ponds at the Mayak Industrial Association

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The radioactive industrial ponds of the Techa cascade at the Mayak Industrial Association are the objects of the elevated environmental hazard, hence, they require control, long-term prediction, and management. The prediction is made on the basis of three models. The first model is based on the subdivision of perennial series of the water-balance elements in the water reservoirs into determined (trend and cycles) and occasional constituents.

The prediction took into account the linear trend and three harmonics with 5-, 9-, and 13-year long periods, the 13-year-long cycle being characterized with the maximum fluctuation amplitude (0.66 m). The trend contribution to the total dispersion was high (above 80%). The prediction is made up to the year of 2008. The water level will continue rising till the year of 2000 to 219.37 m a.s.l., and then it will start falling. According to the prediction made, the overfilling of the water reservoir will cause the environmental emergency. Therefore, the urgent complex measures are required on stabilization and reduction of the water level.

The second model of the long-term forecast represents a correlation function as the index of the genetic intra-series relationship between the water levels in the 1-, 2-, 3-, and 4-year-long intervals. The correlation coefficients characterizing the closeness of the predicted relationships are equal to 0.989 (sR = 0.004), 0.956 (sR = 0.048), 0.900 (sR=

0.005), and 0.833 (sR = 0.006), respectively; which permits us to forecast the water level variation in the reservoirs for 4 years ahead.

The third multifactor model appears to be best of all substantiated by the genetic relationships. The main predictors are as follows: atmospheric precipitation, evaporation, the disposal of liquid waste of the Mayak facility, and the difference between the ground-water recharge from and discharge to the ponds.

The levels and volumes of water in the industrial ponds, as well as their annual increments are of particular practical interest as the predictants. The correlation matrix, characterizing the closeness of the predictor-predictant relationship forms the basis of the forecast calculation. The relationship between the water-volume increment and atmospheric precipitation, evaporation, and water inflow from the adjacent reservoir appears to be best substantiated genetically and statistically reliable.

The contributions of atmospheric precipitation, evaporation, and inflow from another reservoir constitute 35, 45, and 10-20%, respectively, to the total increase in the water volume.The values obtained serve as reference points in planning measures on the environmental protection of the Mayak territory. Verification procedure is applied to the methods and results of the prediction. The measures are suggested on regulation of the water balance in the ponds.

Determination of Main Forms of Contaminants in the Bottom Sediments and Water of the Radioactive Waste Reservoirs at the "Mayak" Production Association

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The main forms of the chemical elements existing in aqueous solutions and bottom sediments should be revealed to model numerically various processes which control the contaminants migration in the ecosystem including reservoirs of the "Mayak" PA nuclear waste.

The published data on chemical and radiochemical analyses characterizing the condition of the subjects of investigation since the beginning of the operation of the reactor (1948) and radiochemical enterprises (1949), as well as the data on the composition of the liquid nuclear waste thrown down both into the Techa River and into the reservoirs, were put in use. The hydrolysis, complex formation and mineral formation processes taking place in chemical systems containing radionuclides (Sr, Cs, U, Pu and Co) and a number of macrocomponents (Al, Fe, Cr, Pb, NO_3^-, NO_2^-, CH_3COO^-, SO_4^{2-}, etc.) which were thrown down together with the radionuclides throughout history of PA "Mayak" activity have been considered. The mentioned above macrocomponents substantially affect the radionuclides behavior in the reservoirs. They either limit the migration due to the sorption and coprecipitation, or assist it through complex formation processes. Besides, concentrations of certain of the components, which entered the Techa River and reservoirs, substantially exceeded standard ones for toxic substances.

Calculation of the equilibrium composition of homogeneous and heterogeneous system has been performed using the Gibbs energy minimization method based on the equilibrium constants values accepted in DiaNIK-99 Database. Both stable and unstable equilibria have been considered. Calculation were performed in a wide pH-range from 2

(Metlinsky Pond) to 9 (Karachay Lake) and temperature range from -5 to 25 Centigrade and for various conditions controlling the oxygen and carbonic acid content in solutions.

Personal reflections on the First Russian-American Collaboration in the Mayak/Lake Karachai Area

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In the autumn of 1994, a team of scientists from U.S. laboratories traveled to the eastern slopes of the Urals to join with Russian colleagues in evaluating the hydrological and hydrogeochemical setting of ground water migrating from a discrete site of high radioelement concentration. The groundwork for this collaboration had been carefully laid during the previous year by patient communication between the scientists, beginning with meetings in Moscow followed by extensive e-mail correspondence. This initial effort resulted in a clear understanding and agreement of the participants of the goals, level of effort, and equipment requirements of the joint collaboration. It was then incumbent on them to convince the Department of Energy and the Ministry of Atomic Energy that the project should be supported, and this was achieved in a surprisingly short time.

The baseline for the field activities had been established by the Russian workers over several decades by the development of a grid encompassing over a hundred observation wells, providing long-term monitoring of a plume of nitrate-laden, moderately radioactive ground water, moving through fractured rock from a disposal lake containing high concentrations of fission products. By collaboration on new sampling and measurement techniques, the 1994 field exercise confirmed the position of the plume and confirmed the efficacy of the sampling methods used over the years by Russian scientists. The subsequent collaboration in assembling and interpreting the results, presenting, and ultimately publishing them was truly rewarding. The U.S. team were tremendously impressed with our Russian colleagues inventiveness in an era of minimal resources, and were pleased that we were able to participate in evaluation of this critical area and to help pioneer Russian - American collaboration on an important environmental issue.

Hydrology Modeling

Strongly Heat-Driven Hydrological Processes in Unsaturated Fractured Rock: Modeling of Field Experiments

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This paper presents a study of flow and transport processes in unsaturated heterogeneous geological systems with a heat source. Heat-induced phase transitions in liquid water introduces a new dimension to flow and transport in a partially saturated rock. The presence of fractures adds further complexity to the strongly heat-driven hydrological processes. Typical permeability to fluid is several orders of magnitude higher in rock fractures than in the rock matrix. At ambient temperatures, the much smaller pores in the rock matrix (relative to the fracture apertures) give rise to strong capillary suction for liquid water, thus resulting in considerably higher liquid-water saturation in the rock matrix, while the fractures are mostly filled with air. At elevated temperatures, as water boils in response to heating, vapor is generated inside porous matrix rocks. Because of its much smaller density in comparison to liquid water, this vapor will pressurize and flow (mostly through the more permeable fractures) away from the boiling region, towards cooler zones where it condenses. One clear manifestation of the heat-driven hydrological processes is the time evolution of moisture redistribution from the vaporization and condensation processes. Further, heating induces mechanical changes through the opening and closing of fractures, and the accumulation of condensate at elevated temperatures promotes chemical reactions such as dissolution and precipitation of various minerals.

For gaining a better understanding of these coupled thermal, hydrological, mechanical, and chemical processes in fracture rocks, An *in situ* heater experiment is presently underway in an underground facility at Yucca Mountain, Nevada, USA in the densely fractured welded tuff formation. The heater test consists of a nearly 50-m-long, 5-m-diameter heated drift into which nine canister heaters were placed. Extending from either side of the heated drift are rod-heaters installed in 25 equally spaced 12-m-long boreholes. Heating was initiated at 185 kW in December 1997 and will continue for four years. Approximately 3,700 sensors were installed in 147 boreholes (ranging in length from 20 to 40 m) and on the drift surface to continuously monitor the temperature, gas pressure, humidity, mechanical displacement, and stresses of the fractured rock in response to the heat generated. In addition, active field measurements by cross-hole radar tomography, neutron logging, electric-resistivity tomography, and interference pressure response to air injection are performed quarterly to track the redistribution of moisture in the rock block from boiling, vaporization, and condensation. Gas and water, if present, are also collected periodically from selected boreholes in the test block for chemical and isotopic analysis. Numerical models accounting for all relevant heat-transfer and fluid-flow processes, including coupling of thermal, hydrological and chemical processes have been constructed to interpret the test data. Aside from proper accounting of physical and chemical processes, we find that it is also important to represent the complex test geometry in three dimensions realistically, and to incorporate site-specific preheat characterization data as input parameters in the numerical models. Comparison of predictions and test data to date indicates that our fundamental understanding of the thermally driven processes is sound: there is good agreement on the

predicted and measured temperatures, zones of drying and wetting, and chemistry of the fluids, all as a function of time. On the other hand, effects arising from specific fractures cannot be predicted a priori. However, measurements and modeling efforts to date have given us much insight as to how spatial heterogeneity arising from fractures impacts the non-isothermal flow and transport processes.

System Modeling of the Interaction Between Surface and Ground Water

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The objective of the paper is to give a survey of the mathematical modeling of the interaction between surface water and groundwater. Besides describing the existing approach to such modeling and the main difficulties in its realization, the paper presents a brief review of the principal works, including Russian material, on the subject under consideration. The construction of such a coupled model requires the development of methods of conjunction between models. These must represent surface and subsurface flows, describe the different processes of water transfer and transformation that constitute the hydrological cycle, and include the different components of hydrological, hydrogeological and water management systems (water bodies, streams, aquifers, etc.). Such models are of different complexities and have different dimensionality in space variables. The characteristic time-scale of transient processes for surface water and groundwater differ greatly, and this is of profound importance in the numerical modeling of their interconnected motion.

The paper contains a survey of analyzing the representative problem for the case in which the groundwater moves within two quite permeable layers that are hydraulically interconnected through a semi-permeable intermediate layer. For the description of the behavior of surface flows in an open-channel network within the region under study (e.g. within a drainage basin), the one-dimensional equations of open-channel flow (the Saint Venant model or the diffusion wave model) can be used. The paper demonstrates the results of numerical experiments for the cases with pronounced interconnection between surface and ground waters.

A Simple Mathematical Model for Infiltration BMP Design

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Infiltration trench is one of the most commonly used stormwater best management practices (BMPs). It is space saving, pollutant removal effective, and pro groundwater recharge. It is favorably used in highly urbanized areas where space is tight and soils are usually moderately to rapid permeable. Infiltration facilities also become necessities to

mitigate groundwater recharge impacts by new developments under more and more local and state regulations. However, an infiltration trench is more difficult to design than an open pond due to the complicated subsurface hydrogeologic conditions. The infiltration rate is determined not only by the permeability of the soil, but also by the geometry of the trench and the water depth in the trench. An accurate infiltration rate is critical for an appropriate design of flood control and stormwater quality enhancement. On the other hand, to conduct a complete hydrogeologic study for every infiltration trench design would be cost overwhelming for small projects. Therefore, a simple and practical method will be very helpful for the design of small scale projects and the preliminary design of large scale projects. This paper presents a simple mathematical model of infiltration rate calculation for circular and rectangular shaped infiltration facilities. The model is verified by in-situ percolation tests and provides satisfactory results. Some design recommendations are also discussed based on first hand design experience.

GIS Based Hydrogeological Data Models for Groundwater Modeling in Mesoscale Pleistocene Water Catchments

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To evaluate agricultural landscape development, there is a need of investigations of the water and matter budget in the mesoscale. Groundwater is one of the most dominating compound in the hydrological and matter-related system of younger pleistocene catchments in NE-Germany.

In this area with an extreme heterogeneity of hydrological and geological boundary conditions, a high density of data will be necessary to describe the hydrogeological situation accurately. Data collection using boreholes and mapping results requires expansive financial efforts, therefore such methods are not practical in mesoscale groundwater modeling. Instead, a practical hydrgeological data model has to be developed to model the hydraulic groundwater component applying known determininstic groundwater models e.g. Modflow, Mike She and Feflow. It should be able to represent the heterogeneity of the hydrogeological situation with scale-dependent parameters.

Based on GIS technologies a method was developed to describe the hydrogeological conditions of aquifer systems in pleistocene regions larger than 200 km^2 using available hydrogeological data and digital elevation models. The resulting data models describe the real heterogeneity of the hydrgeological situation by exercising systematically simplifications using transmission and weighting of scale depended parameters. The level of simplification is adaptable to the requirements of the model.

The application of this method will be shown by modeling results of groundwater movement and matter transport in a mesoscale pleistocene aquifer system with an area of 2400 km^2 in the state of Brandenburg, NE-Germany.

Hydrogeological Substantiation of Numeric Filtration and Hydrogeological Models Using Geophysical Data

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Generally, for adequacy of numeric hydrogeological models of environmental conditions, the results are obtained by using a complex set of field studies, including reconnaissance, drilling and pumping-injection tests, and hydrogeochemical, radioisotope, and geophysical investigations.

Geophysical research allows us to obtain the characteristics of filtration and the hydrochemical situation of the areas, which have not been covered by the data of drilling and pumping-injection works. The latter becomes possible when applying analytical and empiric relationships between hydrogeological and geophysical parameters.

On the basis of our test works performed in various regions, the combined use of surface, aquatorial (water area), and well logging geophysical methods are the most effective to obtain the initial geophysical information. The obtained data reveal the filtration heterogeneity of aquifers, the parameters of deposits along the bottom of surface water flows and reservoirs, and the location and relative intensity of sources of subaqueous ground water discharge. Data also allow us to determine the interface of fresh and brackish water and to detect and delineate the sources of ground water and soil contamination.

Geophysical data were widely used in the development of numeric models of fresh ground water areas with complex hydrogeological conditions for the water supply of the cities and towns of the Primorski region (Vladivostok, Ussurisk, Artem) , Tatarstan (Almetievsk, Bavly, Aznakaevo), and Yakutia (Neryongri) . Based on this geophysical data, the results of steady state and inverse problems modeling showed that hydrogeological and hydrogeochemical conditions reproduced on the numeric model are in accord with the natural hydrogeological situation. This contributed to the validity of forecasting for well fields operations.

Modeling the Impact of Cumulative Additions of Water from Suburban Development on Hydrologically Sensitive Areas

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Many environmental regulations require an analysis of cumulative impact that may result from proposed actions, however, the effects of suburban development on groundwater are rarely considered. In Massachusetts, increased runoff from developed areas may severely impact a site founded on marine clays where water tables are near the surface and hydraulic conductivity of the subsoils is low. Although mounded septic systems are permissible in such areas, there is concern that cumulative hydrologic inputs from surface and subsurface sources may raise groundwater levels significantly in this hydrologically sensitively environment and create problems for the long term. A numerical model that can accommodate a moving boundary (water table) has been used to investigate the cumulative effects of surface water recharge and septic system

discharge on a hydrologically sensitive area. Key parameters are analyzed for relative significance and the potential to identify problem sites through field investigations.

Prognosis of Alluvial Aquifer Exploitation Effects by Application of Models

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Streaming and balance of ground waters was simulated on January 4, 1998, by hydrodynamical source model of the town of Cacak in Serbia. The created model shows the earlier aquifer exploitation in unconventional conditions with the capacity of 95 l/s. in such conditions the main underground influx was coming from the direction of Zapadna Morava. There was a simulation performed on the existing model - the prognosis of the exploitation effects through the increase of underground influx by the infiltration basin. As the result, the source capacity of 210 1/s was gained. The source was regenerated, according to the simulated conditions, and exploited in the period of 1990-1993. The projected capacity was reached by building of eight infiltration basins, whose surface counts 8600 m2 and fourgeen dug wells.

Application of Integrated Hydrologic Models for Wellfield Management and Ecosystem Protection

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Increased demand for potable water supply in the Tampa Bay area is a stress on the available water resources of the region. An adequate supply or potable water at reasonable cost is critical to the vitality of the area. Both resource managers and water suppliers are seeking to maintain sources of supply and the health or the ecosystem. Appropriate allocations of available resources that balance various demands are required. Even with ample water resources due to rainfall averages that exceed 50 inches per year, water resource management that accounts for the highly irregular temporal and spatial distribution of rainfall is critical to protect natural resources while providing reliable supplies. New approaches in water resource management are required, including advanced tools for simulation and analysis of hydrologic system behavior. To that end, Tampa Bay Water, a Regional Water Supply Agency has supported major consultant and staff efforts to develop an integrated surface water and groundwater (15GW) model of the Central Northern Tampa Bay (CNTB) area. The model domain includes 11 wellfields that supply water to the six Member Governments. The integrated model is expandable to cover areas that may serve as future sources of water supply. Currently, the model uses rainfall data from 10 gages located throughout the area and simulates

water withdrawals from all permitted wells within the area. Simulation results from the integrated model are used to develop an Optimized Regional Operations Plan (OROP) for the Agency's wellfields to minimize environmental impacts, meet the water supply requirements of the Member Governments, and satisfy Water Use Permit regulatory criteria.

The 15GW has two major components to simulate surface and groundwater processes (HSPF and MODFLOW); these are linked by a number of intermediate codes to transfer data between the two main modules. The model database currently covers the period 1971 to 1998. Aquifer drawdown response factors developed from 15GW are used in ~ comparative optimization analysis to select among alternative management scenarios to operate the 11 wellfields. This presentation describes data analysis, the 15GW application, forecasting methods, and interpretations that are the basis for the Optimized Regional Operations Plan in support of management decisions for the wellfields.

An Averaging of Hydraulic Conductivity an Transimissivity by Radial Flow toward a Well in Heterogeneous Aquifers

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The goals of the investigation are a) to find the upscaling rule and relationship between the local-scale hydraulic conductivity and the apparent conductivity value obtained from the steady-state pressure tests in radial flow toward well and b) to estimate the transmissivity in the point of pumping well location by using specific discharge in well. Small-value perturbation analysis with a generalization of the first-order product is used to conjecture the relationship between the local-scale hydraulic conductivity and the conductivity value obtained from the steady-state pressure tests. Using numerical modeling of flow toward a well in statistically heterogeneous aquifer validates conjectured expression.

The main results are:

- An equation for the expected mean of the apparent conductivity of radial flow for the general quasi 3-Dimensional flow case was proposed. Comparison of the conjectured equation with the numerical simulation of flow toward well in a heterogeneous aquifer shows that numerical and analytical results quite agree in a broad range of local-scale conductivity variance for 2-Dimensional and 3-Dimensional cases.
- For the lognormal distribution of local-scale transmissivity of 2-Dimensional radial flow in a heterogeneous aquifer an analytical expression for the correlation between the spatially averaged apparent transmissivity found by using

Homogenization of Two-Phase Flow in Aquifers with Micro Heterogeneities

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Contamination of groundwater by dense, non-aqueous phase liquids (DNAPL) has become a topic of great interest. These liquids are highly mobile and move as a separate phase in the groundwater system. Many soils and geological formations contain small-scale heterogeneities, which have distinctly different multiphase flow properties than the main medium. These micro heterogeneities play an important role in the spreading of non-aqueous pollutants. They are often sources of localized pools of pollutants such as DNAPL. Commonly, one is not interested in the details of fluid distribution in such a medium. Moreover, it is often computationally not feasible to discretize a compositional multiphase model at such small scales.

Homogenization approaches have been developed for and applied to the case of two-phase flow in heterogeneous medium. In these methods, the porous medium is conceptually replaced with a homogeneous medium with equivalent multiphase flow properties. Most of these approaches focus only on the upscaling of saturated hydraulic conductivities and calculating an equivalent permeability for the heterogeneous media. There are a few approaches that also include appropriate constitutive relationships of multiphase flow for the resulting homogeneous medium. This study aims at comparison these two approaches. Numerical simulations are carried out for both heterogeneous and homogeneous representations of the aquifer. The homogenization of the aquifer is performed based on both approaches mentioned above. The comparisons of fhe simulation results show the importance and necessity of upscaling the constitutive relationships for two-phase flow in an aquifer with micro heterogeneities.

Modeling Turbulent Solute Transport in a Cavernous Aquifer

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Mass dispersion in a turbulent fluid has not been widely studied in the subsurface because most groundwater flow through porous media is laminar. As part of an aquifer storage and recovery (ASR) study, a fully developed turbulent flow model is utilized for the injection phase of ASR, the velocity profile and the eddy diffusivity of which arc established by physical parameters. Theoretically, the transport of particles can he fully understood by solving the governing differential equations if the turbulent velocity held is completely known (generally impossible). A semi-empirical velocity distribution equation, based on flow through parallel plates and circular tubes, has been developed to predict the advective transport component of the mass transport equation. Both flow and mass transport are simulated using a cylindrical coordinate system. A laminar flow model is applied to the recovery phase of ASR. Chemical tracer measurements conducted

by the U.S. Geological Survey in the Lower Floridan aquifer for several injection, storage and recovery cycles were used in the calibration process.

Modeling of Fluid-Rock Interaction in Porous Medium with Variable-Type Chemical Reactions

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Spreading of dissolved substances in groundwater is to a great extent controlled by their interaction with enclosing rock minerals. Mathematical models that are used to describe and forecast the spreading of reactive solutes in groundwater incorporate mass transport processes and a fixed set of chemical reactions taking place in the system. The set of reactions sufficient for exhaustive description of the chemical interaction in the system is determined by algebraic relationships. Also, each reaction is assumed to have a definite type (reversible or irreversible) throughout the process time.

An important class of processes associated with the formation of geochemical barriers is accompanied by changes in the conditions of matter migration, which are related to changes in the direction of the relevant chemical reactions. In such cases, dissolution of some minerals can give place to their precipitation and vise versa. The proposed approach provides a description of the dynamics of water—rock interaction with allowance made for changes in the type of chemical reactions, e.g., from irreversible dissolution to reversible precipitation.

The developed model can be applied to both natural (e.g., ore formation) and human-induced processes. Application of the model to the description of contaminant spreading in groundwater is considered.

The Model NICHE and Its Application in Eco-Hydrological Impact Assessment

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The model NICHE (Nature Impact assessment of Changes in Hydro-Ecological systems) was built in 1996 by Kiwa (The Netherlands) to predict the impact of water

management on ecosystems. In Russia, it is important to assess changes in plant communities due to water table drawdown as a result of groundwater withdrawal. In order to solve this problem, HYDEC (Russia) acquired NICHE in 1998.

The ecological model NICHE has some advantages in comparison with other similar models:

- It can be used for modeling on both local and regional scale;
- It requires a limited number of initial data, which are easily obtainable;
- It can be used in many geographical regions.

The prediction of areas with plant communities is based on the relation of these communities with nonbiotic environmental factors. Ecological scales, soil maps and data concerning highest and lowest groundwater level are needed for calculation of the nutrient availability, soil acidity and the prediction of plant communities.

Initial data include: groundwater depths (from hydrogeological model) and highest and lowest groundwater levels, land use, soil types, plant communities, and extra sources of nitrogen and acid (fertilizers, atmospheric deposition etc.).

Examples of NICHE application show the ecological impacts by water management in the Havelterberg area (Overijssel, The Netherlands) and by planned groundwater withdrawl in the Oka valley (Moscow Region, Russia).

Initial and output data are given in ARC/Info program. Recently Kiwa and HYDEC developed NICHE in the Arc/View program, which is more friendly for users.

Simulation of Multi-Scale Environmental Impacts Using the EDYS Model

Terry McLendon and W. Michael Childress

Ecological risk assessment (ERA) is a process for predicting ecological responses to scenarios involving multiple environmental stressors. A limitation of many ERAs has been the lack of a robust simulation model that

1. integrates impacts of multiple stressors on large numbers of ecological variables,
2. projects these impacts at multiple spatial and temporal scales, and
3. is adaptable to a wide range of geographic, ecological, and management scenarios.

EDYS (Ecological DYnamics Simulation) is a PC-based model designed to predict changes in ecological systems resulting from natural and anthropogenic stressors. EDYS consists of climate, substrate, plant animal, hydrological, spatial, and landscape modules. The soil module is subdivided into layers characteristic of the application site. The plant module includes above- and below-ground components for each species of interest. The stressor module includes contaminants, drought, nutrient availability, herbivory, fire, trampling, shading, and competition. The hydrological module simulates precipitation, infiltration, runoff, sediment transfer and subsurface movement of contaminants. The landscape module incorporates multi-scale simulations from 1 m^2 quadrats to entire landscapes and watersheds (1-100 km^2). EDYS has been used in ecological risk assessments, impact assessments of environmental changes on erosion and water supply, and simulation of ecological responses to stressors on military reservations, mines, national parks, and watersheds in the United States and Australia. Example applications for the US Air Force Academy and a uranium mine are presented t o illustrate landscape-level hydroecological responses to training, fire, drought, heavy metal contamination, grazing, and revegetation.

Hydrology Case Studies

Volcanic Belts Hydrogeological Systems of Coastal Areas of the Pacific Segment of the Earth

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The Pacific segment of the Earth is the largest tectonic structure of the planetary type and includes actually floor of the Pacific ocean and also its framing folded areas limited by the Siberian, North-Chinese, South-Chinese and Australian platforms in the west, the North-American and South-American platforms in the east and the Antarctic platform in the south. The most specific feature of the geological structure of the segment is the existence here of volcanic belts of various structure, petrology and age. There are intraoceanic volcanic belts, volcanic belts of external and internal island arcs, intracontinental volcanic belts. The particular place is occupied by the marginal-continental volcanic belts. They extend with breaks almost along the whole coastal zone of the Pacific ocean. This is the only place on the planet, where the volcanic belts of marginal type are developed. In the whole marginal-continental volcanic belts of coastal areas being of the same type of structures, have however specific features, including hydrogeological. Proceeding from structural-geological conditions it is possible to single out a number of hydrogeological systems composed volcanic belts of such type. Accumulation and formation appropriatenesses of ground waters within the volcano-structure are the basis for the apportionment of main types of hydrogeological systems. The section of volcanogenic strata is heterogeneous on body morphology and collector types of ground waters accumulation. Stratal accumulations with vesicular and fractured collectors are timed mainly to young (Quaternary and Paleogene-Neogene) volcanogenic strata mainly of basic composition (basalts and andesite-basalts) and volcanogenic-sedimentary deposits. Effusive strata of acid and intermediate compositions form the ground waters accumulations only in the top fractured zone as they are dense. It is predicted on geophysical materials, that the majority volcanogenic hydrogeological systems extend into adjacent water areas of the Pacific ocean or its seas. The ground waters natural resources in hydrogeological systems of volcanic belts are formed either within the limits of the whole volcanogenic strata composed of effusive rocks of the basic composition (as stratal accumulation) or in the top fractured zone of effusive rocks of intermediate composition. Ground waters natural resources in the basic types of hydrogeological systems of volcanic belts drain into the rivers, into the coastal zone of the seas, into the coastal-subaqueous part and probably into the deep subaqueous zone.

For volcanic belts hydrogeological systems of coastal areas of the Pacific segment of the Earth the module value (defined by ground water flow into the rivers) of ground waters natural resources on volcanic belts is (l/s-km2):
2.9 -the East Sikhote-Alin', 1.8 - the Okhotsko-Chukotskiy, 4.0 - the South Korean, 6.0 - the East-Chinese and the South-Vietnamese, 3.0 - the North-American, 8.0 - the Central-American and 12.5 - the Andian (the South-American). Such difference in module value is accounted for climatic, orographic, geologic and other features of these regions.

A Case Study of Groundwater Use and Water-Level Declines in Coastal Karst Aquifers of the Adriatic Coast (Croatia)

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Numerous papers have been dedicated to the problem of fresh water use in the case of salt water intrusion into collectors in coastal karst aquifers. In this paper, possibilities of separating the influence of sea within localities with an incomplete lateral (partly eroded) barrier, are discussed. As in the case a barrier is eroded to a limited depth and at a limited area, effects can be expected by use of a grout curtain connected to impermeable sides and footwall. Such an intervention, with previous experiments, was performed in the area of hollow Trstenica near Orebic (Croatia). The results are presented in a significant part of the paper. Here, among all, at places of eroded flysch zone (along the total length over 130 m), concrete walls are built (between plus/minus 3m peak elevations), Obtained results were used to verify the accuracy of applied concept of solving the problem.

Water and Sediment Quality of a Mediterranean Sea Coastal Area Containing Underwater Archaeology of Ancient Alexandria, Egypt

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The present paper describes the hydrography and environmental conditions of an important Mediterranean Sea coastal zone (the Alexandria Eastern-Harbor) that is holding several of invaluable underwater archaeology of ancient Alexandria. The historical hydro-graphical and chemical characteristics of this coastal zone during two important stages, before and after 1993, are reviewed. The year 1993 is the year of blocking most of the sea outfalls of Alexandria Wastewater effluents that were discharging to the Alexandria coasts and diverting them to an inland lake, called Lake Maryout, South of Alexandria. A comparison is made between the water quality of the present coastal area and that faraway an offshore deep-sea area conducted during 1996.

Multi-Disciplinary Approach to Groundwater Resource Assessment, Northwest Botswana

Vincent W. Uhl, Jaclyn A. Baron, Anthony J. Rana

A multi-disciplinary approach was applied to a 12,500 km2 study area in the Kalahari Desert and on the distal end of the Okavango Delta in northwest Botswana to delineate areas for groundwater exploration in a heretofore unexplored area. The project resulted

in the delineation of 10,000 million cubic meters (MCM) of fresh groundwater in storage and a development program for sources of sustainable supply to the town of Maun.

The study area was mainly in the Kalahari Desert with a minor portion within the seasonal swamps of the Okavango Delta. This paper focuses on the project Inception Period which consisted of six months of data analysis that identified promising areas for groundwater exploration to be addressed by ground geophysics, test drilling and aquifer testing during a 12 month Field Investigation Program.

During the Inception Period, existing data was analyzed from the viewpoint of many disciplines. The principal technologies employed included tentative analysis, geomorphologic studies, structural geological evaluation, surface water flow data analysis, limited surface and airborne geophysical studies, stable isotope sampling, and field hydrogeological reconnaissance.

Satellite imagery was studied and a vegetative analysis conducted to evaluate areas of shallow groundwater potential on the basis of species classification. Geomorphic evaluation involved a study of the evolution and configuration of the very subtle drainage ways that comprise the delta distributaries. Surface water flow characterization was utilized to assess drainage ways/river flow characteristics and to evaluate optimal areas for exploration on the basis of recharge potential. Preliminary surface geophysics utilizing the TEM (transient electromagnetic) method indicated that shallow aquifer systems along drainage ways were characterized by a shallow fresh water lens (on the order of 50 m thick) and of limited areal extent (1 to 2 km width). The stable isotope sampling of selected existing wells (18O and deuterium) indicated that surface water infiltration is the principal recharge mechanism in the area.

The synthesis of the investigative results from the various disciplines resulted in the delineation of six areas for exploration drilling. The findings of a subsequent large-scale airborne electromagnetic (AEM) survey and the exploration drilling program confirmed that five of these areas contained considerable reserves of fresh groundwater. Three of the exploration areas were subject to annual recharge where a developed source would be sustainable by replenishment from surface water infiltration.

Permafrost

Tracking Arctic Contamination Episodes with a Geographic Information System

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A geographic information system (GIS) of arctic contamination, which is being assembled at the U.S. Naval Research Laboratory, can be used to discern historic trends in the distribution of contaminants and suggest the principal transport mechanisms. The GIS can also provide data with which to validate contaminant transport models and to project the fate of these contaminants.

Information from the GIS suggests that sources of Arctic radionuclides were not static over the past half-century, but evolved over time. Prior to 1960, the principle radionuclide sources were atmospheric test sites on the Novaya Zemlya, the central Pacific Ocean, and the continental United States. In the decades of the 1960s and 1970s the Ob' River became an significant source of radionuclides. In the decades of the 1970s and 1980s contamination from the Sellafield (Cumbria, England) nuclear reprocessing plant became apparent. In the late 1980s-1990s radionuclides from the Chernobyl accident could be tracked. Present-day sources of radionuclides in the high arctic water and sediments probably stem from non-atmospheric FSU sources. Some of the radionuclides found on the continental shelf north of Alaska are probably from FSU sources. These radionuclides were probably not transported directly between the Chukchi and Beaufort Seas but rather via the Trans Arctic Drift and the Beaufort Gyre. Data suggest that canyons in the Russian continental shelf act as transport highways for contaminants to the inner Arctic. Based on studies of clay and total-organic carbon in the water columns, the regions of seafloor most easily contaminated are the Bering Sea near the Aleutian Islands, the Chukchi Sea east of the Lena Delta, the Kara Sea, and the Barents Sea. The data also suggest that should there be a release of radionuclides from Murmansk into the Barents Sea, the most likely contaminant-transport pathway would be to the northeast along a seafloor channel containing fine-grained sediments.

The concentrations of organochlorine compounds and heavy-metal species in water, ice, and sediments are also elevated along the Russian continental shelves. Across the North American Arctic the transport paths of organochlorine compounds and heavy-metal species can be easily tracked in the marine and terrestrial environments, suggesting contaminants from Eurasia are carried by interrelated transport mechanisms involving air, water, and ice.

Understanding the Effects of Discontinuous Permafrost on Contaminant Migrations

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A study was conducted to provide a quantitative description of the effects of discontinuous permafrost on subsurface hydrology and contaminant transport for the

groundwater system at Ft. Wainwright. This analysis involved the use of SUTRA, a numerical model that allowed us to predict the likelihood of various contaminant pathways. To accomplish these objectives, we initiated a series of data collection efforts including the procurement of groundwater samples to allow us to determine water chemistry both organic and inorganic, the measurement of water surface elevations, the collection of meteorological data, characterization of the soils, and the injection of a tracer followed by subsequent sampling of the groundwater and analysis of the samples.

We used all of the above information to help us in developing a site conceptual hydrogeological model and calibrating our contaminant transport model (SUTRA). The former is essential to the development of any groundwater flow or contaminant transport model. Phenomena such as recharge magnitude and the channeling of flow into permafrost free zones can have dramatic effects on the fate of pollutants as predicted by appropriate models. The information derived from the tracer studies provided us with crucial data regarding groundwater velocities and dispersion. These are crucial input parameters for the advection-dispersion models used to predict plume migration. Extensive effort was invested to determine the accuracy of our chemical analyses and the variation that can be introduced during sample collection.

SUTRA, Saturated-Unsaturated TRAnsport, a two-dimensional finite-element model was applied to Operable Unit 3 (OU3) area on Ft. Wainwright in order to determine the effect discontinuous permafrost has on the subsurface hydrology and contaminant transport. Data from a tracer study was analyzed first in order to get field estimates for dispersion coefficients and hydraulic conductivities. Then, the entire source area within OU3 was modeled using benzene as the contaminant. The model results showed permafrost to act as a significant retarding force in contaminant transport to the point of stalling movement completely in some cases. Discontinuous masses of permafrost redirected the groundwater and created steeper gradients, thus, changing the local hydrology significantly. Sensitivity analyses indicated concentrations were most affected by the source strength and the permafrost configuration. These results may be affected by the two-dimensional nature of SUTRA, but indicate a strong influence by the permafrost on the hydrology and transport pathways.

Considerations in Contaminant Migration in Permafrost Regions

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Contaminants behavior in polar regions is affected strongly by presence of permafrost and subfreezing conditions. Our understanding of water transport in actively freezing soils is primarily limited to studies of frost heave while less work has been done on the concomitant mobilities of water and solutes in frozen soils. Unfrozen water may exist in soils to temperatures well below the freezing point depending on the solute concentration, soil texture (specific surface area), and soil mineralogy. Self-diffusion coefficients of water and selected solutes can be measured directly in frozen porous media utilizing NMR techniques, and chemical equilibrium models are being developed to predict the unfrozen water and solute concentration. These studies along with studies of bulk diffusion provide guidelines for understanding mobilities of solutes in frozen soil. In addition to diffusion, rapid advection of water into frozen soils and transport along the

base of the active layer (annually thawing top layer) are important considerations in contaminant mobility and dispersion in soils of permafrost regions.

Stratigraphic Layer and Anomaly Identifications using a Hierarchical Neural Network for Interpretation of Ground Penetrating Radar

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Ground-penetrating radar (GPR) is a powerful tool to examine the structure and properties of media below the ground surface within depths of 10-30 m. This study is very important for the cold regions environmental problems related to the transport of contaminants in groundwater. Successful GPR profiling of the subsurface media to delineate the distribution of permafrost, water table, and bedrock depths is critical for successful groundwater flow modeling. Similarly, the system can be instrumental in identifying anomalies that do not match the expected stratigraphic layers.

This work develops a hierarchical processing system capable of handling GPR data characterized by high degree of uncertainty, natural physical ambiguity, and, sometimes, missing or incorrect entries. The hierarchical nature of the algorithm allows one to split the task of media profiling into several consecutive stages, each of which has a lower degree of uncertainty than the previous one.

Neural network modules are designed to accomplish two main processing goals: recognizing the "subsurface pattern" or the presence of an anomaly, followed by identifying the depths of the subsurface layers like permafrost, the groundwater table, and bedrock. A preprocessing procedure transforms raw GPR data into a small feature vector containing the most representative and discriminative features of the signal which are used as inputs for the neural network processing units.

The separate system components are implemented in software and tested with synthetic and actual GPR data. The algorithm demonstrates correct and accurate results. It is tolerant to significant noise/error levels. The developed (trained) software is fast enough for real-time, field-operations in conjunction with industrial GPR equipment.

Two Aspects of the Hydrology of Siberian Permafrost Terrains

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Recent research results on two aspects of permafrost hydrology, runoff dynamics and reservoir behavior, will be presented. A noteworthy study on the runoff formation of in northern areas of Siberia has recently been completed by L.S. Kuchment, A.N. Gelfan, and V.N. Demidov of the Water Problems Institute of Russian Academy of Sciences, Moscow. They developed a physically based distributed model of snowmelt and rainfall

runoff generation in the permafrost regions. The model included snow-cover formation and snowmelt, thawing of the ground, evaporation, basin water storage dynamics, overland, subsurface and channel flow. The model also included influence of the depth of thawed ground on water input, water storage, and redistribution of water input between surface and subsurface flow. The model was applied to the Upper Kolyma River basin with a catchment area of 99,400 km^2. It was found that, when compared to colder climates, runoff generation in regions with a moderate climate plays a smaller role of infiltration of water into soil and a greater dependence of runoff losses on the depth of thawed ground.

The presentation will conclude with a discussion of studies on the behavior of reservoirs that were created in the permafrost areas of the NorthEast Siberia (e.g., Vilyui and Kolyma reservoirs, among others.).

Management of Subsurface Brine Problems during Deep Open-Pit Mining in the Northern Regions of Russia

V.A. Mironenko and F.G. Atroschenko

Operation of deep open-pit mines is often accompanied by appreciable upconing of brines to drainage systems and concomitant contamination of the extracted brines. Large volumes of salt water may be brought to the surface posing a potential for significant environmental contamination.

The kimberlite pipes in Yakutia are reached by deep open-pit mines. Under permafrost zones roughly 200 m thick, the pits intersect brine horizon in carbonate stratum, which is about 150-200 m thick. The total salt concentrations in the brines are between 100 to 300 g L-1 and their inflows to quarries could reach 1000 m3.hour-1 and more. The lack of technologies for utilization of brines removed by drainage systems contributed to the deterioration of the region's environment - particularly its surface-water quality. Two approaches to the problem have been developed.

The first approach consists of the construction of deep grouting walls to reduce brine seepage into the pit. For example, a semipermeable wall more than 300 m deep (below the permafrost zone) and roughly 3 km long was constructed along the perimeter of the "Mir" mine pit. The wall with a thickness of 10-20 m or more was formed by injecting a special clay-cement mixture via wells into fractured rock. It was assumed that this wall would reduce the permeabilities 2-3 orders of magnitude - from meters per day to centimeters per day, thereby reducing seepage in to the pit by an order of three to four. A set of aquifer tests and observations has been developed to assess the permeability of the constructed curtain. They have proved that its efficiency was much less than anticipated.

The second approach is to reinject brines underground away from the pit. For this purpose the same carbonate stratum can be used at distance of several kilometers from the quarry, as it is done now at the "Mir" open-pit mine. On the other hand, at "Udachnaja" open-pit mine the main volumes of brines are injected into carbonate-clay rocks of permafrost zone - with due account of its storage capacity, - "free" (after leaching of ice) porosities are typically on the order of 3-4 %. Taken over a whole formation this volume is sufficient to dispose of virtually the entire brine discharge volume into the permafrost zone - with negligible environmental damage. It is necessary, however, to use as much of the available space in the permafrost zone as possible to prevent the injected brines from leaching quickly into the main brine horizon (located under permafrost zone). To accomplish this, the brine recharge is to be realized via

systems of shallow wells. Due to the layered structure of permafrost zone the brines move laterally over the distance of some kilometers from the injection site, gradually leaking to lower horizons of the permafrost zone. The appropriate system of observation well was substantiated for monitoring the dispersion of the injected brines.

Computer Modeling of Thawing and Chemical Interactions Attending Burial of Heat Generating Nuclear Waste in Permafrost Limestone

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A pilot project for isolating radioactive wastes in perennially frozen bedrock is under development on the Novaya Zemlya archipelago. Steel containers with heat generating spent naval nuclear-reactor fuel will be placed at a depth of about 20 m in trenches dug in limestone perennially frozen bedrock. The heat will thaw some of surrounded permafrost.

A computer model simulating physical and chemical processes attending such burial is being developed for design and risk assessment. The first version of the model that has been developed consists of two modules: 1) heat and mass transfer and 2) chemical equilibria.

The heat and mass transfer module explicitly includes decrease of the energy release due to radioactive decay, water's enthalpy effusion as well as conductive and convective energy transfers. The module calculates the temperature distribution around the container given its contents, size and shape of the thawing zone, and convective water flows in the thawed zone.

The second module calculates chemical interactions in various parts of the repository using temperature and mass balance as the input parameters. Calculations are based on thermodynamic properties of the rock-forming minerals, aqueous species, and the substances which the spent nuclear fuel and the container consist of. This makes it possible to simulate both corrosion of the steel container and, should the container be breached, the dissolution and/or precipitation of uranium and plutonium.

This model has been used to test various scenarios. The life-time and size of the thawed zone have been estimated depending on the input parameters. The mechanisms and velocity of steel corrosion as well as the range of possible of radionuclide concentrations in the pore solutions of the limestone have been determined.

Permafrost Area as a Potential Source of Replenishing Collections with Pathogenic Microorganisms

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At present, the main source of establishing or replenishing collections of pathogenic microorganisms are fresh clinical isolates, which can differ significantly from their predecessors that caused outbreaks many years ago. A comparative study of "old" and "new" strains is undoubtedly of scientific and practical importance; it allows following evolution processes that took place in the population.

A useful evolution landmark would be the isolation of viral genetic elements from the end-of-the-last-century burial sites in the northeastern permafrost zones of Siberia. Spanish influenza and smallpox outbreaks have often affected regions in the Northeast of Siberia. From the beginning of monitoring in the 17th century, more than ten outbreaks with mortality rates higher than 40% have been registered. The smallpox outbreaks of 1884-1889 were the most severe ones. Moreover, these burial sites still remain potentially dangerous for the emergence of viable viruses. This threat is most serious in the case of variola virus because of its high stability.

To assess long-term variola virus viability, we have undertaken an investigation of viruses from patients' crusts (typical skin rash). The crusts have been kept for 26 years in sealed test tubes at a temperature of -20°C. The results show that we could isolate infective viruses from practically every sample under study. The quantity of infective virus was estimated 3.7±0.4 lg PFU per individual crust on the average. The decrease in virus content after 26 years of storage was 2.0-2.5 lg PFU. These data suggest that infective viruses in the crusts may survive more than 250 years under given storage conditions.

At analogous burial sites in moderate and hot climates, this problem has been studied intensively. It was suggested that the only microorganism capable of long-term survival in burials is *Bacillus anthracis*. Microbial long-term survival in permafrost zones has not been investigated convincingly.

Our Center has the facilities to work with pathogenic microorganisms at all biosafety levels. Currently, we investigate the long-term viability on variola virus and influenza virus, etc., by studying their nucleic acids in samples from the permafrost zones.

Technical Innovations

Long-Term Performance Assessment of Permeable Reactive Barriers to Remediate Contaminated Ground Water

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Permeable reactive barriers (PRBs) are an emerging, alternative in-situ approach for remediating groundwater contamination that combine subsurface fluid flow management with a passive chemical treatment zone. The few pilot and commercial installations which have been implemented thus far have proven that passive reactive barriers can be a cost-effective and efficient approach to remediate these compounds. However, in all of the pilot and commercial installations to date there has been very little data collected or research focused on the long-term performance of these in-situ systems, particularly with respect to the build-up of surface precipitates or bio-fouling. A detailed analysis of the rate of surface precipitate buildup in these types of passive in-situ systems is critical to understanding how long these systems will remain effective. Different types of minerals and surface coatings have been observed to form under different geochemical conditions, which are dictated by the composition of the permeable reaction zone and aquifer chemistry. Microbiological activity impacts are also important to understand and better predict how long these systems will remain effective in the subsurface. This project will assess long-term performance at three PRB sites: 1) the Elizabeth City USCG site in North Carolina, 2) the Somersworth landfill Superfund site, Somersworth, New Hampshire and 3) the Denver Federal Center site in Lakewood, Colorado. Work to date has focused on analysis of trends in ground water quality parameters, surface analysis of recovered iron from the wall over a period of two years, and assessment of microbiological activity within the wall and at the upgradient and downgradient interfaces. This is an abstract of a proposed presentation and does not necessarily reflect EPA policy.

Reactive Iron Well, Tacony Warehouse, Philadelphia, PA

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The Baltimore District and Fort Dix, NJ implemented a innovative application of the reactive iron technology in order to meet specific site requirements for the treatment of TCE contaminated groundwater at a Base Realignment And Closure facility. The groundwater at the former manufacturing site is influenced by tides in the Delaware River. Rather than installing a proposed slurry cut-off wall, U.S. Army Corps of Engineers Baltimore District and Radian, the District's Pre-placed Remedial Action Contractor contractor, chose to install a large diameter pumping well where the reactive iron was substituted for the sand filter pack. This design created and in-situ reactor that treats the TCE contaminated groundwater as it is extracted. Water is treated by reductive dehalogenation reaction that occurs while the water is in contact with the iron filings.

Reductive Detoxification and Immobilization of Chromate Present in Soils

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The in-situ permeable reactive barrier at the U.S. Coast Guard Air Support Center at Elizabeth City, NC is very effective in remediating the contaminant plumes of TCE and chromate in the ground water, but it has limited effectiveness to attenuate chromate present as sorbed phases in the vadose zone. Manipulation of the oxidation-reduction (redox) status of a vadose zone is a viable approach for in-situ remediation of a redox-sensitive contaminant like chromate. It was hypothesized that by creating a reducing zone through introducing a reductant into the vadose zone, the soluble and sorbed CrVI will be reduced and precipitated resulting in an immobile and less toxic Cr(III) mineral phase. Therefore, the objective of this study was to evaluate potential reductants and their effectiveness to reduce highly Cr(VI)-contaminated soil or sediment samples collected from the vadose zone beneath the plating shop area of the U.S. Coast Guard Air Support Center at Elizabeth City, NC. The reductants evaluated were sodium dithionite, l-ascorbic acid, and hydroxylamine. These reductants reduced chromate present in soils/sediments, and each provided a unique geochemical environment. Sodium dithionite proved to be the most effective reductant to detoxify chromate present in the vadose zone materials. This research will contribute to the development of a cost-effective remedial design to attenuate redox-sensitive contaminants present in vadose zones.

Simultaneous Removal of the Adsorbale and Electroactive Metals From Contaminated Soils and Groundwater

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In-situ permeable reactive barrier technologies have been proposed as a lower cost alternative to traditional methods of groundwater remediation such as pump-and-treat. Groundwater contamination at wood preservative facilities often contains metals mixtures. Among common metals formulations used as wood preservatives are copper, chromium, and arsenic (CCA), and ammoniacal copper zinc arsenate (ACZA).

Copper, zinc, chromate, and arsenate are toxic elements and potentially hazardous. The physical and chemical properties of metals in aqueous solution are quite different. Cu(II) and Zn(II) are cations and strongly adsorb on oxide surfaces in soils, while Cr(VI) and As(V) are oxyanions and redox sensitive under environmental conditions. Cr(VI) forms ($HCrO_4^-$ and CrO_4^{2-}) are the greatest environmental concern due to their toxicity and mobility, while Cr(III) is less toxic and is removed from solution as the $Cr(OH)_3^0$ precipitated phase. Contrasting to Cr(VI), the reduced forms of arsenic (As(III), $HAsO_2$ and AsO_2^-) are more toxic and mobile than the oxidized forms (As(V), $HAsO_4^{2-}$ and $H_2AsO_4^-$).

Metals can be removed from contaminated groundwater by adsorption and/or reduction onto iron-oxide minerals (e.g. hematite and biotite). Iron-oxide-coated sand (IOCS) has been successfully used in our lab in both batch and column reactor experiments to remove lead from aqueous solution. Magnetite-coated sand (MCS) is a mixed oxidation state (ferrous-ferric) oxide, providing both adsorption and reduction

capacities for simultaneous removal of Pb(II) and Cr(VI) from aqueous solution. In a mixed metals contaminated ground water (e.g. Cu(II), Cr (VI), and As(V)), MCS can be used to for simultaneous removal of Cu(II) by adsorption, Cr(VI) by reduction to Cr(III), and As(V) by adsorption without reduction to As(III). One possible advantage of MCS is that it adsorbs As (V) and prevents it from reducing to the more toxic and mobile As(III) species, compared to the metallic iron (Fe^0) which is thermodynamically favorable for reduction of both Cr(VI) and As(V).

Mechanisms in In-Situ Thermal Remediation

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The physical properties of fluids and their interactions with soil will control their movement in the subsurface, as well as their recovery. All of these properties are temperature-dependent. In addition, various types of liquid and vapor movement can be created in porous media due to temperature gradients. Understanding these temperature effects and their relative magnitudes is important in understanding how in situ thermal remediation processes can be used to enhance the recovery of organic contaminants. For volatile organic compounds, which includes fuels such as gasoline and diesel and chlorinated solvents, the main mechanism for enhanced recovery is the increased vapor pressure with temperature which allows these compounds to be recovered in the vapor phase. Enhanced solubility and decreased adsorption at higher temperatures will also contribute to the recovery of these chemicals. The recovery of semivolatile and (essentially) nonvolatile oils can be enhanced at higher temperatures through viscosity reduction, increased relative permeability, and decreased capillary forces. These changes in physical properties allow oils to be displaced in the liquid phase when there saturation is greater than residual saturation, and also tend to decrease the amount of residual saturation. Field and laboratory experience demonstrates that even semivolatile organic compounds can be distilled at significant rates when high temperatures and low vapor phase pressures conditions are created.

New Developments in Groundwater Monitoring and Measurement

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This presentation will discuss recent USEPA efforts to promote the use of effective innovative tools applicable to site characterization and monitoring. Information presented will cover USEPA initiatives related to the following topics:

- Direct Push Technologies for groundwater sampling and the installation of "monitoring points": Evaluation study; DP Workgroup; Case Study Report
- Monitoring and Measurement Technologies for the 21st Century ($A21M^2@$): EPA Office of Solid Waste and Emergency Response (OSWER) initiative to identify and deploy new systems for monitoring hazardous waste sites
- Sensor interest and support: Internet sensor development communication website;

down-hole TCE and BTEX sensors, RDX and TNT measurement

- Environmental Technology Verification (ETV) Site Characterization and Monitoring Technologies Program (SCMT): Well-head monitoring for VOCs reports and Brown Bag presentation; groundwater sampling demonstration
- Superfund guidance under development to support field analytical contracting issues, implementation, and quality assurance issues.
- Field-Based Site Characterization Technologies and Strategies course offered by EPA: current 4.5-day course; new modules being developed to support field analytical implementation and quality assurance

Push-Pull Studies Using Radon-222 to Monitor the Remediation of Napl

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One of the major obstacles preventing cost-effective cleanup of many sites is the current inability to accurately locate and quantify residual nonaqueous phase liquid (NAPL) contamination. Additionally, monitoring NAPL removal during and after remediation is desirable to quantify the extent of cleanup achieved, and to verify the cost-effectiveness of the applied technology. The recently developed natural radon-222 (Rn) tracer method has the potential to provide a rapid, low-cost, nondestructive, and noninvasive method for routine use in quantifying residual NAPL in the subsurface.

The method is based on Rn's high solubility in organic NAPL. In the absence of NAPL contamination, aqueous Rn concentrations reach a maximum site-specific value based on the aquifer porosity and mineralogy. In the presence of NAPL, aqueous Rn concentrations are substantially reduced as the Rn partitions into the residual NAPL. The resulting 'Rn deficit' can be quantitatively correlated to the degree of NAPL saturation. Thus, it is possible to quantify the presence of residual NAPL and assess the effectiveness of remediation efforts by measuring the Rn concentration in groundwater produced from existing monitoring wells. The transport of Rn is also retarded due to the partitioning of Rn into the NAPL phase. Thus Rn can be used as a natural partitioning tracer in dynamic transport experiments.

Results will be presented from small- and intermediate-scale laboratory experiments, field studies at NAPL contaminated sites, and analytical and numerical modeling evaluations of these studies. The Rn method was successfully demonstrated in a series of laboratory NAPL remediation experiments, which utilized large, radial-flow physical aquifer models containing aquifer solids contaminated with trichloroethylene (TCE) as a NAPL phase. Static aqueous Rn profiles were measured before and after TCE emplacement, and also during treatment. The static Rn deficit profiles accurately reflected the location of the TCE and were also consistent with contaminant mass balances. Increases in Rn concentration were correlated with NAPL remediation. Dynamic push-pull transport experiments showed that Rn was retarded due to the presence of NAPL. Field studies at NAPL contaminated sites and model simulations are used to illustrate dynamic and static Rn responses associated with the presence of NAPLs. There are several limitations that must be considered when using the Rn method. Geologic variability in mineralogy and porosity affects background Rn concentrations. The Rn signal is not propagated long distances from the NAPL source

due to Rn's short half-life. Also the mixing of Rn depleted groundwater from NAPL zones with background groundwater reduces the Rn deficit signal. A push-pull dynamic test has the ability to overcome many of these limitations since the test is based on the retarded transport, which would have less of a geologic dependence, especially if tests are repeated as NAPL remediation proceeds.

Rapid Site Characterization of Skeet/Firing Ranges using Field Analysis by Energy Dispersive X-Ray Fluorescence (EDXRF)

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This presentation describes the use of a field portable energy dispersive X-Ray Fluorescence (EDXRF) instrument for characterizing heavy metal contamination in soil at multiple firing ranges at the Presidio San Francisco and a skeet range at Defense Depot, Ogden, Utah. In addition, the presentation will explore some of the myths, benefits and issues surrounding the use of XRF for site characterization.

X-Ray fluorescence, long a laboratory research instrument, is now beginning to be used in the field to characterize heavy metal contamination in soils. Characterization of firing ranges with lead contaminated soils is an ideal use for XRF. As the unit is able to give quantitative results for multiple metals within 20 minutes of sampling, site characterization activities can be easily altered based on real-time XRF analytical data to achieve maximum use of personnel and equipment. In short, metal contamination at any site can be characterized both horizontally and vertically in one field mobilization. Using traditional "hunt and peck" sampling with laboratory analysis, site characterizations can often drag on for years.

Results of using XRF analytical methods for numerous firing ranges at the Presidio San Francisco will be presented, including the sample decision protocols and use of other innovative technologies (Global Positioning System) which resulted in the successful characterization of all the ranges within 4 weeks.

Barriers to the use and acceptance of XRF will be discussed. Currently such barriers include gross misconceptions by consulting firms and regulatory agencies as well as technical issues.

Cometabolism of Chlorinated Aliphatic Hydrocarbon Using Propane and Butane Utilizing Microorganisms

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Propane and butane-utilizing microorganisms are being studied for their ability to cometabolize chlorinated solvents. Propane and butane-utilizers are well suited to transform mixtures of chlorinated methanes, ethanes, and ethenes. For example butane-utilizers transform 1,1,1-trichloroethane (1,1,1-TCA), and its abiotic (1,1-dichloroethene [1,1-DCE]) and biotic (1,1-dichloroethene [1,1-DCA]) transformation products. Thus at sites where 1,1,1-TCA is a contaminant, mixtures of these three compounds could potentially be degraded by microorganisms grown on butane.

A batch incubation microcosm method was used for determining the potential for aerobic treatment chlorinated aliphatic hydrocarbon (CAH) via cometabolic sparging with gaseous substrates. The method was evaluated using both butane and propane as the primary substrates to drive CAH cometabolism. The study was done in support of a field demonstration of cometabolic sparging that is being conducted at McClellan Air Force Base, CA. The microcosms were constructed using aquifer material and groundwater aseptically obtained from two CAH-contaminated sites at McClellan Air Force Base, CA. CAH contamination included trichloroethylene (TCE) at 350 to 1100 ug/L, cis-dichloroethylene (c-DCE) at about 50 ug/L, 1,1-dichloroethane (1,1-DCA) at 10 ug/L, 1,1-dichloroethylene (1,1-DCE) at 6 ug/L, and chloroform (CF) at 2 ug/L. Each microcosm was prepared with approximately 200 ml of site groundwater and 100 ml headspace and 5, 10, or 70 g of aquifer material from the respective sites. Initial studies showed propane was a more effective substrate than butane. Lag times for the onset of propane utilization ranged from 15 days for microcosms containing the most aquifer material (with little CAH contamination) to approximately 50 days for those with less aquifer solids and higher CAH concentrations. Rapid CAH transformation following propane utilization was found in many of the microcosms with up to 140 ug TCE transformed from a single addition of 8 mg propane, resulting in TCE concentrations below 5 ug/L.

Based on the results of these microcosm studies, a field study is being performed where propane and air are being injected into the saturated zone of McClellan AFB. Effective propane uptake was observed in the saturated zone at McClellan approximately 50 days after propane was added, similar to the responses observed in the microcosms. The rate of propane uptake has accelerated with successive additions of propane. Nitrogen addition has not been required to achieve effective saturated zone propane utilization. TCE, c-DCE, CF, and 1,1-DCA are being effectively removed in the saturated zone. Initial TCE concentrations of approximately 1000 ug/L have been reduced by over 90 % at several locations and treatment below the MCL of 5 ug/L may be achieved if reduction trends progress with continued treatment.

Strategies for Bioremediation of MTBE from Contaminated Groundwater

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Methyl *tert*-butyl ether, MTBE, is widely used in modern gasolines as an oxygenating compound and as an octane enhancer. Its consumption in the US is estimated at approximately 2.0×10^{10} gallons/year (Ainsworth, 1991). This compound has recently been detected in groundwater supplies throughout the western US due to gasoline spills and leaking underground storage tanks (UST). Additionally, the US EPA has issued a drinking-water advisory (40 ppb) for MTBE because of carcinogenicity evidence (US EPA, 1997).

Remediation technologies are needed to facilitate a considerable reduction for contaminated groundwater at a reasonable cost. MTBE has a very low Henry's coefficient (Hcc = 0.022 @ 25 °C, dimensionless), it is also highly soluble in water (48 g/L), then it travels conservatively with groundwater (R = 1.05) and faster than more hydrophobic gasoline compounds. Because of these characteristics, pumping and treating remediation is not a suggested technology. Intrinsic bioremediation seems to be not very effective because ether compounds are slowly degrade as primary substrates by either

aerobic or anaerobic microorganisms (White, 1996). Several laboratory studies confirmed that the utilization of MTBE as a growth substrate by bacteria is often a slow process that requires high MTBE concentrations and mixed microbial cultures (Salanitro, et al., 1994). This may explain the longevity of MTBE in the environment and that intrinsic biological processes may be limited for remediation of MTBE contamination.

Recent research at OSU (Hardison, et al., 1997; and Hyman, et al., in press, 1998) has demonstrated that a wide variety of alkane utilizing microorganisms, including bacteria (Mycobacterium vaccae) and filamentous fungi (Graphium sp) can cometabolically degrade MTBE after growth on simple hydrocarbons (such as propane and isopentane). This process is directly analogous to the aerobic process recently developed for the degradation of chlorinated solvents such as Trichloroethylene (TCE) (McCarty, et al., 1998).

Several themes have emerged that suggested potential in-situ remediation approaches for MTBE removal from groundwater. Without exception, propane-oxidizing microorganisms appear to be capable of cometabolically oxidizing MTBE. The use of propane stimulated microbial activity would be expected to be effective for the remediation of low concentrations of MTBE found down gradient from point sources of gasoline contamination.

MTBE degrading activity is also observed when microorganisms are grown on the individual major aliphatic, rather than aromatic, components of gasoline. This indicates that substrates that can support MTBE degradation are present within gasoline itself and that significant reduction in MTBE can be expected if cometabolically degradation of MTBE is promoted at the point source containing gasoline compounds.

Because of the difference in enzymatic ability to degrade MTBE, it appears that bacterial systems may be advantageous near the point source of gasoline contamination where both MTBE and the necessary co-substrates remain as mixtures and at high concentrations. At large distances from the point source, the fungal system with the addition of propane may be advantageous because of the small concentrations of MTBE.

Poster Session:

Contamination: Assessment and Remediation

Effect of Impurities Associated with Aluminosilicate Minerals on Sorption and Oxidation of Arsenic

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Anthropogenic arsenic is an important source of environmental pollution. The most common inorganic arsenic species in the environment are arsenate, As(V), and arsenite, As(III). Arsenite is more toxic and mobile. Risk assessment and risk management of arsenic contaminated sites requires a better understanding of arsenic-mineral interactions. Aluminosilicate minerals, such as feldspars and clays, are the most abundant constituents occurring in aquifer sediments, soils, and as suspended particles in groundwaters and surface waters. Naturally occurring substance (e.g., iron, manganese, humic acid) can associate with minerals, consequently, they could affect the interaction of arsenic with mineral surfaces. Investigation of the effect of impurities on the adsorption and oxidation of arsenic is rare. This experimental work demonstrated that Fe and Mn coatings on feldspar and kaolinite could alter the surface physicochemical properties of the minerals, causing a great increase in the adsorption of arsenite and arsenate. Minerals treated with humic acid showed significant decrease in the adsorption of arsenate, but had little change in the adsorption of arsenite. The oxidation of As(III) to As(V) was significantly catalyzed by iodine ions associated with the clays. The investigation suggests naturally occurring impurities, although they may be trace in quantity, could significantly affect the adsorption and oxidation of arsenic in the environment.

Microbiological Estimation of the Quality of Groundwater Containing Iron and Manganese under an Anthropogenic Impact

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For estimating the quality of natural groundwater, a method of bioindication has been used. The main indices are the structure of a microbiological community and the ratio between the number of heterotrophic and oligotrophic bacteria dwelling in water-bearing rocks. The structure of the microbiological community regularly changes depending on the location and depth of a well, drilling methods, chemical composition of pumping waters, as well as the duration and intensity of groundwater pumpage.

A special place is assigned to a particular group of iron- and manganese-oxidating bacteria, which is able to use reactions of iron and manganese oxidation as an energy source for substance exchange. For the purpose of using groundwater containing iron

and manganese as potable water, it is proposed to use the natural potential of bacteria of this group by means of artificial saturation of them by oxygen.

In natural conditions, pH and eH are insufficiently high. Thus, for iron and manganese oxidation, the activization of life activity in microbial communities is required. Under artificial saturation of groundwater by oxygen in the course of well drilling, eH is increased from 0 (-10, -30) mV up to 250-500 mV, and pH is increased from 6 to 7 and more. Water-bearing rocks of a stratum around a well and bacteria being reproduced in them promote iron and manganese oxidation directly in situ. A certain time will be required when oxygen sorption is happening on the surface of rock particles in a stratum and biomass of iron and manganese-oxidating bacteria is rather enlarged. The reduction of iron and manganese is at the expense of forming hydrate oxides and their accumulation in biomass of bacteria attached to rock particles.

Chemical Composition Changes of Fresh Ground Water of the Middle-Amur River Artesian Basin at Water Intake Areas (The South of the Far East of Russia)

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The iron and manganese content in the fresh groundwater of the Middle-Amur River Artesian Basin is unsteady, not only over the area and through the vertical section, but also in time. The major transformation of the chemical composition of fresh groundwater occurs as a result of a change in iron and manganese contents in the water, especially at the initial period of water intake exploitation.

Regarding Komsomol'sk-na-Amure, observations on the first water intake demonstrate a stable increase of iron for the last 10 years from 2.0-6.0 mg/dm3 up to 8.0-14 .0 mg/dm3, and manganese from 0.5-1.1 mg/dm3 up to 0.7-2.0 mg/dm3. By 2006 it is predicted that there will be an increase of iron up to 16.0-23.0 mg/dm3, and manganese up to 1.8-3.3 mg /dm3.

Over 50 years of exploitation of the second water intake, there was a shift from 0.1-0.5 mg/dm3 up to 2.0-3.0 mg/dm3 for iron, and up to 1.0 mg/dm3 for manganese. It is forecast that the increase of iron will be up to 4.0-5.0 mg/dm3 and manganese up to 1.2-1.8 mg/dm3 in this water intake by 2006.

During three years of the third water intake exploitation, the content of iron has increased from 8.0-12.0 mg/dm3 up to 25.0-30.0 mg/dmB (concerning separate wells - up to 55.0 mg/dm3) and the content of manganese has ranged from 0.2-1.0 mg/dm3 up to 1.0-2.2 mg/dm3.

In Khabarovsk over the last 20 years, the tendency of increasing iron and mangenese amounts has been observed over many water intakes: the first water intake (iron - up to 1.8 mg/dm3, manganese - up to 0.95 mg/dm3), the second one (iron - up t o 30.8 mg/dm3, manganese - up to 1.96 mg/dm3), and the third one (iron - up to 11.0 mg/ dm3, manganese - up to 0.91 mg/dm3)

The content of iron and manganese amounts in the water of water-intake wells is related to water pumping amount. This is why in the case of the increase of water pumping at these sites, we might expect greater concentrations of iron and manganese.

When new water intakes are beginning to exploit, it is necessary to take into account

that just during the first year of their working, the contents of iron and manganese can more than triple.

The application of modern and effective methods of ground-water purification from higher concentrations of iron and manganese is an important measure for the environment al condition of the Middle-Amur Artesian Basin. The method of ground-water intrastratal purification, which has passed the control tests at water intakes of Komsomol'sk-na-Amure and Kheberovsk, may be the most effective here.

Transformation of Water and Contaminants Flow in the Channels of the Moscow River - The Main Source of the Moscow City Water Supply System

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A half of water volume necessary for the Moscow city water supply is taken from the upper basin of the Moscow river from 7500 sq.km of watershed. The Moscow river flow and the flow of tributaries is regulated seasonally and annually by four water reservoirs with total drainage area 4240 sq.km. Unregulated part of the basin equals about 40% of the total catchment area. This area is subject to heavy human activity , which considerably influences water quality particularly during flood periods. Information on water pollution sources and on the dynamics of its propagation in the channel network is essential for better control of water quality. A special complex computer program for management of water quality when accidental heavy pollution of water happens is worked out.

The program includes:

- A mathematical model of snowmelt and rainfall runoff formation from the unregulated part of the river basin for computation and prediction of flow.
- The program part for computation of water propagation in the channels.
- The program part for computation of dissolving and selfpurification of polluted water during its propagation downstream.
- The scheme for selection of better source for water supply when accidental point watershed pollution happens.

Test computations show effectiveness of the model for taking operational decisions for reliable water supply of the Moscow city and for lessening of losses due to pollution accidents in the river basin.

Problems in the Identification of Sources of Hydrospheric Organic Pollution

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A broad range of natural and artificial compounds brought into the environment in the course of man's economic activities is leading to the fact that the said substances are becoming, in a number of cases, main pollutants, determining the character of hydrosphere technogenic pollution. First and foremost, the said is concerned with the

mining regions, characterized by a wide spectrum of organic compounds coming into hydrosphere (components of oil, oil products, some kinds of ores; rocks and fluids attendant to them; chemical compounds brought in during the processing and benification of minerals.

The experience of hydrogeochemical research shows that, in many cases, it is difficult to give clear identification of the nature of hydrosphere organic pollution, due to the following factors:

- complicated character of spatial and temporary redistribution of organic compounds in hydrosphere at the expense of a wide scope of solubility, adsorption properties and other factors;
- relatively quick transformation of initial organic substances at the expense of their geochemical and microbiological destruction processes;
- imposition of technogenic constituent over the natural background of the water-dissolved organic compounds, the role of which in hydrosphere, in some cases, is compared with the scope of organic pollutants brought in.

The experimental research on the peculiarities of hydrosphere organic pollution has been considered in mining areas of two types: oil-producing areas in Western Siberia (combination of considerable scopes of organic pollutants coming into hydrosphere with high natural organic background, being formed by peat organic) and potash companies in the PreUrals (transformation of potash wastes, organic constituent of which is connected with the use of organic reagents in the process of benification).

Alongside with the results of complex study on the water-dissolved organic substance composition (infrared spectroscopy, thin-layer and gas-fluid chromatography, chromato-mass spectrography), the data of model experiments on the interaction of "oil-water", "peat-water", "waste-water" systems are presented.

The results of the research show that a considerable amount of organic compounds is located within the natural geosystems in the form of mineral-organic complexes, biogeochemical transformation of which is leading to their release into water-soluble substances and to the formation of secondary hydrosphere organic pollution centers. The processes, taking place here, are leading to a considerable change in composition of water-dissolved organics, in comparison with that of the initial one, and that makes the identification of pollutant sources brought in rather difficult.

The main methodical approaches to the study on hydrosphere organic pollution character in oil-producing areas are considered, allowing one to carry out the identification of possible pollutant sources.

Long-Term Monitoring of Unsaturated-Zone Properties at the Bemidji Crude-Oil Spill Site

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Ground-water recharge is an important factor affecting the Bemidji, Minnesota crude-oil spill site. About 400,000 liters of crude oil remained in the ground after remediation was completed following the 1979 pipeline break. An automated data logging system was used to measure unsaturated zone properties relevant to estimating recharge and to evaluate their effects on dissolution of the oil. Laboratory and field testing of several soil-moisture probes indicated that the CS615 probe was better suited to estimating recharge in the glacial outwash at the Bemidji crude-oil spill site than the CS605 probes. Both probes are manufactured by Campbell Scientific Inc. The CS615 probe provided

dependable and accurate data over long time periods, using a limited power supply, under the extreme weather conditions typical of northern Minnesota. Based on results of the testing, arrays of the CS615 probes, zero-maintenance tensiometers, and thermocouples were installed in the unsaturated zone at the north oil pool in the fall of 1998. Computer simulations indicated that the rate of dissolution from the oil body is linearly related to the recharge rate. Additional multiphase flow model analyses are being conducted to quantify this increased dissolution. Additional model analyses are also being conducted to evaluate how dissolution is affected by recharge that varies in relation to the presence of crude oil in the unsaturated and saturated zones, discontinuous lenses of lacustrine silt and clay, and topography. The VS2DT code is also being used to estimate recharge rates and to evaluate the movement of water through the oil.

Combining Active and Passive Techniques for the Remediation of an Acrylonitrile Release in the Subsurface

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A failure in a buried product pipeline resulted in the release of acrylonitrile (AN) to a silty, clay rich unsaturated soil and ultimately to underlying groundwater. Following a detailed hydrogeologic investigation to define the concentration, rate and extent of AN movement in the subsurface, a two-phase remediation program was implemented. The first phase consist of active removal of the highest concentrations of AN using extraction wells and off-site treatment of discharge water. The second phase passively monitors the effectiveness of natural attenuation of residual AN concentrations and provides necessary information to adjust the active removal system to insure minimal product migration. Periodic monitor well network sampling with analyses for AN, acrylamide, acrylic acid, acetic acid, propionic acid as well as other indicator parameters has confirmed consistent degradation of AN. Threshold concentrations below which significant AN degradation is initiated and the decay half live variability of AN and degradation daughter products in groundwater were determined. In less than two years, a fivefold decrease in AN groundwater concentrations have been documented.

Poster Session:

Water Resource Assessment and Management

Peculiarities of Water Regime of Forest Ecosystems in the North Sikhote-Alin

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On the example of the basin of the Tormasu River located in the northern part of the Sikhote-Alin Ridge, peculiarities of water regime of forest ecosystems are considered. The Tormasu River basin occupies the western slopes of Sikhote-Alin Mountains with absolute marks up to 400 m in the River valley and up to 1500 m on the watershed. The territory relief is a rugged topography characterized by middle mountains. In the bounds of basalt development, the relief is plateau-like. In geological sense, this region is formed by terrigenous-sedimentary rocks of Triassic-Cretaceous age, igneous rocks of basic and acid composition as well as by many intrusive and extrusive rocks.

Among forest ecosystems there are distinguished: secondary small-leaved forests after cuttings and fires along the river valley, mixed coniferous-broad-leaved and broad-leaved forests on slopes and coniferous forests on the watershed.

One of the key peculiarities of forest ecosystems is their moisture regime. The basin of the Tormasu River is characterized by the following water features: precipitation is about 800 mm, the river runoff is 450 mm, and evaporation is 350 mm. As to the River valley, its groundwaters are at the depth of 3 - 5 m, during floods their level rises and sometimes is near the surface. This fact creates the transit regime of a substance in ecosystems. On slopes of valleys the aeration zone is 5 - 10 m and present itself by gruss-detrital rocks and its thickness is closely related to the regime of precipitation and their infiltration. In the period of dry months the humidity of rocks towards the depth of 3 - 5 m does not exceed 8 -10%.

Interstream areas are sometimes flat, and planed with the developed crust of weathering of clay composition that is favourable for the leakage water formation (lens of wetting clay-detrital rocks lying on clays). This promotes sufficiently satisfactory humidity regime of ecosystems and they functionate quite normally, but under anthropogenic impact (fires, cuttings) the humidity regime can be changed and sometimes very strongly. Probably, the same moisture regime has mixed coniferous-broad-leaved forests at an altitude of 1500-2000 m in the north part of the Cascade Mountains and analogous problems appear under anthropogenic impact.

Principles and Methods to Provide Hydroecological Situation Analysis for River Basins

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The hydroecological condition of rivers is a function of geographical and hydrological factors, and of the mode and degree of natural resources usage. Analysis of river basins by hydroecological condition has to consider char-acteristics of the water body and its anthropogenic impact.

In some cases, a combination of the factors mentioned causes critical ecological

situations, varying in their evolution. To develop the methods of ecological situation rehabilitation, it is necessary to consider the similarity of geographical and ecological characteristics such as:

- runoff formation zonal conditions having influence on supplying the territory with water and therefore, diluting the water bodies' physical and chemical regime and biological processes, which determine their self-purification scale;
- stream dimensions which determine the discharge of the stream and the transformation difference of incoming pollutants in similar environment conditions;
- morphodynamical type of channels;
- the character of seasonal runoff variations which reflects seasonal variations in the rivers' diluting potential;
- the character of the streams' hydraulic condition.

Authors applied principles and methods listed above in the solution of hydroecological problems for Beloretsk reservoir (Belaya River) , for Moscow River and for Volga basin.

Application of the Criteria for Hydroecotoxicological Situation (Hets) Assessment depending on the Status of Environmental Utilization for Arid Zones

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Based on a summary of the literature and our own standpoint we may identify HETS as a complex of knowledge of the sources, scale, assortment (toxic components) and the ways of contamination of the hydroecosystems, behaviour, quantitative characteristics, toxicant migration and their impact on hydrobionts at various levels of separate or a group of ecosystems in a river basin or over an entire region.

Of the two existing systems of MPS (maximum permissible concentrations) in the former USSR - sanitary-hygienic and fish-farming, the latter is more suited for HETS assessment as it is based on the biological and physiological criteria. Lately, many scientists propose to develop ecological MPS. However, a generally accepted definition of «ecological norm» is not hitherto available in the literature.

We define «ecological norm» as a certain level of maximum permissible anthropogenic load on a water body or stream which does not cause any changes exceeding historically established fluctuations in the hydrological, hydrochemical, geochemical and hydrobiological processes, which determine structural and functional integrity of the hydroecosystem on the whole. Ecological norm takes into account not only the water quality but also the bottom sediments, plants, fish and other components of the hydroecosystems.

Thorough analysis of the water bodies used in industry shows that ecological norms are not applicable to absolutely all hydroecosystems. Expediency of their application depends on the importance and the status environmental utilization of the water body.

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Risk Assessment of Flow Managing of the Water Catchment Systems of Middle Asia

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This report gives an account of choice possibilities between two alternative variants of the water supply improving within plains: by regulation of surface or river bed run-off. Regulation of riverbed run-off by means of reservoirs creation gives a prompt results, increasing water supply of the areas requiring irrigation. However we have accumulated some facts indicative of secondary negative consequences and of positive effects' short duration. The last fact is connected with reservoirs silting up. There have been occasions of reservoirs silting up for 10-15 years. Negative occurrences include first of all discontinuance of the nutritious substances' flow with drifts to the flood plain and to the fields.

As experience of agricultural forest amelioration shows there are numerous reserves of increasing positive effects owing to protective afforestation in the mountains. Besides, putting a price for water in force will considerably increase of agricultural forest amelioration's ability to competition, as the price for water reflects the real expenditure for providing with water of agriculture and other branches of economy.

We offer to include the following indexes to the list of comparative criteria: maintenance of normative terms of repayment, achievement of the outlined effect, improving the living conditions of the local population, absence of serious unexpected circumstances, prevention of negative social phenomena, safety of buildings and communication lines, inviolability of old relics and cultural monuments, supporting of soil fertility, water and air' protection from contamination, flora and fauna safeguarding. The criteria are evaluated according to five-points scale: 1 point is «unlikely», 2 points - «probably», 3 - «possibly», 4 - «provided», 5 - «guaranteed», for all that the points are summarized. We have done he expert estimations of the projects of reservoirs' creation on the middle-sized rivers (such as the Kashkadarya River) and agricultural forest amelioration on the water collector area. It has been revealed that flow management by means of agricultural forest amelioration is much preferable than creation of hydrostations from the point of view of stability of working.

The management of water resources in prospect should be directed to decrease of the negative consequences. The practice shows that the policy of intensive increase in hydrotechnical constructions is unjustified. The positive effect of the outlined measurements is exaggerated, the negative consequences are underestimated, and there is the very essential fact: real term of function of hydrostations is considerably shorter than the calculated one. The concrete examples are adduced in this report.

Peculiarities of the Underground Water-Exchange of Flat Lakes and Reservoirs of an Arid Zone

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An underground water-exchange plays a certain role in water and salt budgets of lakes and reservoirs. Some of its peculiarities are typical only for an arid zone. The Balkhash

Lake is an example of the most complete studies in such an underground water-exchange. The underground water ingress into the lake comes from flows affiliated to river valleys, forming a groundwater recharge by surface water. The zone of the hydrodynamical river influence is not more than 1-2 km. In conditions of an arid climate and low draining of the territory (the gradient of land surface does not exceed 0,0003) just an evapotranspiration from a shallow groundwater level is a factor regulating a groundwater flow. To reach the lake the groundwater flows forming on the drainage area and undraining by the rivers should have discharges, which would enable «an evapotranspiration barrier» to be overcome. With real volume of recharge and geofiltration parameters of aquifers the groundwater flows can not reach the lake. As a result of it depressions of a groundwater level with a semi-stagnant geofiltration regime are formed. The lake water outflow into these depressions is possible.

The formation of an underground outflow occurs as a result of complicated process of an infiltration of lake water into coasts and its intensive discharge in coastal phytohydrogeological systems, inside which there is a basic transformation of surface water into ground water. The analysis of processes of forming of an underground outflow from the lake permits to offer a method of an estimation of lake water abstraction loss into coasts. The lake water loss is estimated by the solution of a set of simultaneous equations of water and hydrochemical budgets of groundwater of this zone. The rather small discharge of underground flows to the level depressions takes out a plenty of the solutes, which tops ingress of them with groundwater into the lake almost 30 times. The major importance in this process belongs to evapotranspiration by coastal phytocenosis.

Ural Hydrosphere

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There are 3 orographic zones: The East part of Russian Plain, Folded mountain Ural and it's mountain ranges, foothills and Ural East slope peneplain. Mountains cross different climatic zones and they separate the climatic areas between Russian and West-Siberian plains. Rock water contents in the Ural East slope is 1,5-2 times less than in the West one.

The most valuable is fresh and table mineral waters of the area of active water circling. In the Pre-Ural there is predominance of pore and stratum pore waters, and in the Ural - crack-veined ones. From north taiga to dry steppe precipitations decrease fumes and water mineralization increase. Hydrocarbonate-silica, hydrocarbonate and sulphate waters are replaced by hydrocarbonate-sulphate-chloride and chloride ones. Increasing of agricultural reclamation of forest-steppe and steppe areas, concentrate on of industrial enterprises and cities along large rivers sharpened water deficit. Mineralization increasing is accompanied with water pollution increasing from north to south and also from watershed to large rivers valleys. There are following hydrosphere transformations:

a) water are polluted by industrial and people life waste materials;
b) increasing nature process intensity of dissolving and rocks melting;
c) increase water selfclearing on geochemical barriers;
d) expand range of influence on hydrosphere during getting minerals out and underground construction;
e) in the nature there's absolutely new synthesis things;
f) besides water resources exhaustion there are more and more often cases of areas flooding.

Fundamentals of the Procedure of the Combined Monitoring in Connection with the Caspian Sea Level Rise

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A steady rise in the Caspian Sea level occurring recently resulted in transformation of the environment in the coastal territories and affected the economic sphere. In addition to flooding of vast areas, the hazardous processes aggravated, among which there are storm surges, off-water, abrasion, rise of ground water, backwater, swamping, etc. This in turn created unfavourable ecological situation: the environmental pollution by petroleum products, heavy metals, organic matters, pesticides, parasitic and bacterial contaminants. Such situation requires the establishing of the system of monitoring the nature and economic facilities, the shore-protecting structures included. Distinguished among natural subjects under monitoring there are components of the environment (soils, grounds on land and on the underwater continental slope, surface and underground water, vegetation), topography and hazardous processes: off-and-on water flood, earthquakes, abrasion (in the coastal zone including the shore line, cliff and underwater slope up to 5-m depth), washout of beach, shore drift, erosion, landslides, downfalls, rise of ground water, swamping, salinization, corrosion, deterioration of the carrying ability of grounds, deflation. The man-made subjects under monitoring comprise: (1) subjects of engineering protection of territories, i.e. shore-protecting structures and drainage systems; (2) economic facilities exposed to hazardous processes, i.e. melioration systems, oil fields, farming lands, settlements, recreation zones, industrial and agricultural facilities, roads, buildings and constructions. The combined monitoring of the natural-technogenic system (NTS) can be subdivided into two subsystems: (a) monitoring of the natural constituent of the NTS, and (b) that of the technogenic constituent. The first comprises the control, prediction and regulation of all components of the environment, including surface water, underground water, geological-engineering and seismic conditions. The monitoring of man-made (technogenic) facilities involves the control and assessment of their state, particular attention being given to the shore-protecting structures and beaches. Basic principles of the monitoring functioning are open opportunities, unification of means, a unified methodical base, relative periodicity, timeliness.

Elaboration of Hydromelliorants for Water Saving Measures

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The polycomplexes is a new class of modificated polymer junctions which are finding practical application like hydrophobias or hydrophyl materials depending on direction of the task as an effective connectors, structure former, mulching materials and soil hydrogels.

Authors created high efficency chemical meliorates on the base of polymer complexes, which can be used for environmental protection (water-air-soil).

The present work is devoted to producing new interpolymer complex of carboxymethylcelluose (CMC) with nitrogenated oligomers and polymers of various structure and their use.

By methods of potentiometric and coductometric titration, spectro-photometry and IK-spectroscopy was conducted fact of formation and structure of interpolymer coplexes. The detected the low of between the structure and properties of interacting compounds and interpolymer complexes obtained have been revield.

Physical-chemical properties of interpolymer complexes with oligomers with different structures and properties have been studied, that allowed to detect the features of complex formation and their productts properties. There is a possibility of structure and properties adjustment of interacting components.

New interpolymer complexes derived turned out to effective structure formers whose use prevents water and wind erosion of soils. An essential advantage of the given reagents involve the fact that the new polymer products are the closest to the natural conditions, and not harmful to the existing biosystems. Prospects of the given series polymers use in water supply systems and agriculture have been demonstrated.

Hydrodynamics of Groundwater Flow in Fractured Zones in the Salt Lake Basin (Republic of Khakassia, Southern Siberia)

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The Salt Lake basin ((250 km2) under study is located in semiarid steppe of Republic of Khakassia (South Siberia). In the mid fifty's the agricultural activities were started where the Salt Lake was shallow swamp with small surface area and a new village Novotroitskoje were created around it. By the mid eighty's, at and around the village, observation wells showed an increase of water table close to the ground surface, which led to increase of the surface area of the lake to almost one half square kilometer at the present time.

The Salt Lake basin is located at the center of the anticline fold, composed of upper Devonian sandstone, argillite, aleurolite. The limbs of anticline fold composed of volcanic sediments, dolomite and limestone. The modern tectonic structure of the upper Paleozoic block to be considered is related to the regional pushing of Southern Sajan mountains which lead to formation of fractured zones in- and across direction of stress. These zones were clearly recognized from satellite images.

The groundwater flow in the study area exists in two distinct regimes: regional flow in exogenous fracture system and local flow in the fracture zones. Numerical hydrodynamic model shows, the increasing of groundwater level and widening of Salt Lake surface area which is related to long term climatic changes in the region, where the increase of yearly precipitation is evidently. It also shows that the fracture zones of the fault systems play a great role in the hydrodynamic structure of the groundwater flow, where they serve as a conduct to the groundwater flow from the lake basin to the outside area. The pinpointing

of the fault zones in small scale and determination of the hydrodynamic properties of these zones are very essential for any dewatering operations of the area in future.

Trans-International Aquifer Analysis: The Mimbres Basin Aquifer of Southwestern New Mexico and Northern Chihuahua, Mexico

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The Mimbres Basin occupies an area of about 4,400 square miles in southwestern New Mexico and about 2,000 square miles in northern Chihuahua, Mexico. Water bearing strata in the basin include consolidated bedrock units in the northernmost portions and highlands of the basin and Tertiary and Quaternary basin (bolson) fill units in the central to southernmost portions of the basin. Recharge to the aquifer occurs mostly from ephemeral recharge along mountain fronts and from infiltration beneath perennial streams. Groundwater flows north-to-south from the northern highlands, across the international border, to phreatic playas in Mexico where groundwater discharges by evaporation. Groundwater also discharges by pumping, by plant transpiration, and by leakage to perennial streams. A numerical flow model linked to a particle tracking algorithm predicts that it takes tens of thousands of years for groundwater to move from the recharge areas in the northern highlands to discharge areas in Mexico.

Hydrochemical facies in the basin vary from calcium-bicarbonate ground waters with total dissolved solids (TDS) less than 500 mg/L in the northern half of the basin, to sodium-bicarbonate ground waters with TDS greater than 500 mg/L near the international border, to sodium-sulfate and sodium-chloride-sulfate ground waters with TDS greater than 1,000mg/L in the southernmost segment of the basin. Different hydrochemical facies and higher TDS develop as groundwater flows from north-to-south. The primary processes responsible for hydrochemical evolution and salinization include gypsum and halite dissolution; exchange on clay particles of bound sodium for calcium and magnesium in solution; and evapotranspiration from vegetation and evaporative discharge at phreatic playas.

Ground-Water Monitoring of the Amur River Basin

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For more than 50 years the groundwater monitoring of the Amur River Basin has been carried out. The major research interests are the following:

- the study of natural and disturbed regimes of pressure-free and pressured groundwater at the artesian basins, volcanogenic basins and hydro-geological massifs;
- the determination of the extent of contamination and depletion of ground water in the

cities (Khabarovsk, Biagoveshchensk, Kom somol'sk-na-Amure, Nikolaevsk-na-Amure, Birobidzhan and etc.) and in the regions of mining enterprises (mainly those with tin output);

- the study of the water balance in the vadose zone and on the reclaimed lands (Middle-Amur intermontane artesian basin);
- and the study of the hydrogeodeformational field of the Earth for the purpose of earthquake prognosis.

As a result of concentrated groundwater pumping in the territories of the cities, the direction of hydrogeodynamical, hydrogeochemical and hydro-geomicrobiological processes has been substantially changed. Also, the rate of their course has been activized. The direction and rate of groundwater movement have changed and their discharge has stopped. The groundwater level has declined and the thickness of the vadose zone has increased. The natural concentrations of groundwater components have decreased or increased or new ones have appeared as a result of technogenous contamination.

Hydrogeomicrobiological processes, the fact of their occurrence has been recently stated, have led to the current lithification of water-bearing rocks. These processes have also led to the formation of natural conditions of groundwater purification at the expense of a combination of unique hydrological and hydrogeomicrobiological processes during groundwater pumping at infiltration water intakes.

Collection of Nationally Comparable and Defensible Water-Quality Data

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The U.S Geological Survey (USGS) recently announced a publication series to document USGS standards and guidelines for collection of surface-water and ground-water water quality data. The purpose of this NATIONAL FIELD MANUAL FOR THE COLLECTION OF WATER QUALITY DATA is to

(1) establish and communicate scientifically sound data collection methods,
(2) encourage consistent use of field methods in order to produce nationally comparable data, and
(3) provide sampling methods that, when properly applied, result in data that are reproducible within defined limits of variability.

The data needed to determine the quality of national, regional, and local water resources are collected by Federal, State, and local governmental agencies, educational institutions, and the professional private sector. Such data-collection efforts consume considerable resources, yet often are duplicated. Duplication often occurs because the data might not be comparable within and among the data-collection organizations owing to differences in sampling techniques and protocols. Data that are not scientifically comparable are subject to potentially costly misinterpretation. Data comparability is essential if the information gleaned is to be synthesized over local, regional, and national scales and shared among the scientific, regulatory, management, and private sectors.

Comparability, reliability, and defensibility of water-quality data depend on the correct and consistent implementation of accepted scientific methods and technical procedures in the collection of these data and on the documentation and quality control of the procedures used. The USGS has developed this NATIONAL FIELD MANUAL series as one part of its program to meet those goals.

Poster Session:

Hydrology Modeling

Calibration of Geofiltration Models Using Extreme Methods of Inverse Problem Solution

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The calibration problem of a geofiltration model is formulated in this work by the following way: to define unknown filtration model parameters and hydraulic potential distribution (spatial or spatial - temporal). The following points are necessary:

a) mass balance law should be valid explicitly for every discrete block of model;
b) calculated hydraulic potential values should coincide with experimental data with accuracy equal to measurement errors in all points of modeled domain where experiment data exist;
c) unknown filtration model parameters are defined in permissible range of values ascertained *a priori*;
d) spatial distribution of unknown filtration parameters contains smoothness in the limits of space zones established *a priori*.

Mathematical formulation of this problem leads to a large sparse nonlinear programming problem. The method of solving this problem is stated in the report The method consists in consequent solution of convex quadratic programming tasks. The possibilities of this method are demonstrated on test problems.

Research of a Ground Water Flow Formation of the Balkhash Artesian Basin with the Help of Mathematical Models

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The Balkhash artesian basin consists of two ones: the Southern-Balkhash and the Eastern-Balkhash. However, their structures of the hydrogeological system, groundwater zonality, rates of water-exchange, conformity to natural lows of groundwater formation differ. The mathematical model of these basins was created on the basis of the data of the groundwater regional study, of water budget researches in separate areas, prospecting for groundwater, etc. The representation of hydrogeological system of the Balkhash artesian basin as mathematical model permits to specify a process of a groundwater formation and to allocate hydrodynamical areas of the free water-exchange zone, i.e. areas of a groundwater recharge and dispersion of a groundwater flow with various mechanisms of these processes.

In the limits of the Southern-Balkhash artesian basin a prognosis simulation of exploitable resources of two groundwater reservoirs was carried out. The results of simulation show, that the groundwater exploitation of these two objects with discharge of

3,46 m3/sec within 50 years could result in essential change of ecosystems of the region. The decrease of the groundwater level could cause a degradation of vegetation communities of Haloxylon aphyllum, replacement phreatophytes by ombrophytes in the area of about 2,5 thous. sq. km. At the confirmation of exploitable resources of these reservoirs this circumstance was not taken into account. Thus, the substantiation of the optimizing criteria of a exploitable resources utilization should be determined by interrelation of hydrogeological condition changes with changes of other components of the ecosystems.

Application of Numerical Modeling to Pumping Tests Data Interpretation under Non-Uniform Hydrogeochemical Conditions

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The Korshunovsky ore deposit (the East Siberia, Russia) has been exploited since 1967. Intensive drainage operations resulted in a large drawdown of the water table (about 250 m) in the vicinity of the ore body. Due to noticeable vertical hydraulic gradients, the natural brine (which was initially located at the depth of 500 m) started moving up. As a result, by the middle of the 90s, the total amount of dissolved solids (TDS) in the drainage water had reached up to 70 g/l in the most contaminated wells.

Thus, a critical environmental situation for the whole region has occurred. In predicting the drainage water TDS variation, an evaluation of flow and transport properties of the rock plays a key role. Relevant parameters can be verified and defined more precisely by including hydrogeochemical information (time TDS variations) in the interpretation procedure. Analytical solutions obtained earlier did not take into account a range of factors, i.e. density advection.

This is the reason we applied a numerical simulation (based on HST3D code) to interpret the field data obtained during exploration of the Korshunovsky ore deposit. Sensitivity analyses for permeability variations and fracture porosity values of separate layers were carried out concurrently. Then numerical modeling was used to discover the semi-empirical relationships. This can help in the analysis of field data based on the typical curves approach.

Use of a Finite Element Code to Model Complex Mine Water Problems

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Numerical models are now used routinely to predict ground-water inflows to both surface and underground mines and to help design dewatering systems. Two of the more complex problems encountered in mine dewatering are 1) predicting the configuration of the phreatic surface and height of the seepage face in pit highwalls for slope stability analysis and 2)

predicting inflow to underground mines, particularly from discrete geologic structures and under non-Darcian flow. Frustrated by the limitations of the most common ground-water flow codes in dealing with these problems, we have developed a 3-dimensional, finite element code, designated *MINEDW*, that has been specially designed to address the relatively unique hydrologic complexities of mining.

***MINEDW* includes subroutines to calculate the height of the seepage face in a pit wall, simulate faults without adding more discretization, and simulating non-Darcian flow and the transition to Darcian flow as heads and gradients decrease. Examples of *MINEDW* solutions to relatively idealized problems are given and compared to those from phisical models, analytical solutions, and another numerical code (*MODFLOW*).**

***MINEDW* has been applied to a large mining operation in Indonesia involving dewatering of both a large pit and underground drifts. This case has been made even more challenging by karstic features and very high, but variable (particularly as demonstrated by a recent El Niño-induced drought) precipitation.**

For Publication Only

Complex Hydrometeorological Risk Analysis for River Flood Control

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Hydrometeorological risk is understood as the probability of a combination of dangerous events and is defined on long series of observations. For full analysis of risk connected with floods are considered: a complex risk assessment with account of all destroying factors; a spatial analysis of flood scenarios using a model of "multivariate flow of correlative hydrological events;" a regional risk degree classification of sections of river valleys and risk maps in different scales.

A purpose of the hydrometeorological risk concept is a rapprochement between a broad qualitative notion about the risk (as dangers) and its quantitative calculation possibilities. The risk analysis, connected with floods, takes into account the whole collection of destructive factors. The risk (as probability) is defined on the absolute and relative probabilities of elementary events. The probability evaluation of the elementary events is executed by direct or indirect methods on the base of hydrometeorological data series. An investigation of dependencies of risk from landscape parameters enables to execute a broad regional generalizing of the risk assessments. It is important particularly for deciding the problems of water management and land use within a territory with a small amount of observed data.

Integral Watersheds Parameters in Flood Cycle Model for Small River Basin

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The model is developed for small rivers with the summer-autumn rain floods prevalence. Followed conditions are satisfied: parameters have a physical sense and are defined without digital optimization; mathematical adaptation on the base of standard observing be wholly correct.

The model is oriented to the description of two runoff formation modes – intercapacity and surface. It covers a dynamics of small watershed near the point of full moisture-holding capacity (FC). The model consists of the three volumes - soil (capillary), gravity and channel capacities. Soil capacity ensures a runoff volume shaping, but gravity and embedded in it channel capacities imitates a hydrograph transformation.

The main parameters are a critical discharge Qcr, a decline coefficient R and the maximum capacity values (FC, capillary-CC and gravity - MGC). The values of FC and Qcr spatially changes are not significant and present themselves as regional constants. The values of CC, MGC and R, opposite, are powerfully changed depending on basin

features. An analysis has shown that the main parameters may be determined for unexplored basins with average mistakes from 5 to 15%. The hydrometeorological accessibility factors (height and orientation of basins), the land-use factors (shares of forest and ploughed areas) and the river network structure factors (order and density) herewith are most informative.

The Role of Ice Formation and Melting in Ecological Geochemical Processes

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The theoretical foundation, the lasting natural observation various data and numerous experiment results analysis (Ivanov, 1998) have substantiated the existence of various ecological-geochemical processes, caused by the formation, presence and melting of natural ice and snow.

They are revealed in the following:

1. Cryogenic concentration of dissolved substances during the freezing of natural waters.
2. Qualitative changes in the chemical composition of freezing waters.
3. Compositional and phase changes of gases in natural ices and waters.
4. Modification of ionic flow in rivers of the Russian and Middle Asian cryolithic zone as a result of ice formation: 1) river ionic flow decreases as a result of cryogenic mineral formation; 2) a seasonal redistribution of river ionic flow.
5. Transformation of the state of ice and water state during melting (the role of melt waters in ecological-geochemical processes): 1) desalination by ice upon melting; 2) formation hydrochemical and hydrobiological stratification of continental and marine reservoirs; 3) contamination of rivers and reservoirs with polluted melt waters: 4) intensification of the ionic flow by the ground waters as a result of the influence of severe snowless winters.
6. The Global ecological-geochemical role of ice and snow formation and melting: 1) Accumulation of $CaCO_3$ and other slightly soluble compounds; 2) the accumulation of soluble substances in multi-year ices; 3) Salinity variations in world ocean waters; 4) salt aerosol formation; 5) gas exchange state fluctuation; 6) the vital activity of the organisms in the interfacial boundary between ice and on water; 7) algae vegetation under the ice: 8) biogenic and organic formation of substances at the water-ice and (water surface) boundaries; 9) land amelioration during icing.

- Turnover of Glaciogenic substances

This analysis has revealed the following characteristics of the ecological-geochemical role of the formation and melting ice and snow: 1) substances are conserved during seasonal and multi-year cycles in sea, lake, river, bog, and underground ice and ice masses; 2) migration of chemical elements slows down and turnover of global, regional and local substances is excluded in yearly, intra secular and multi-millennia cycles; 3) The qualitative composition of natural waters and river chemical flow transformations take place; 4) river chemical flow volume decreases and flow of suspended substances increases; 5) partial river chemical flow redistribution from winter period to spring-summer occurs; 6) of the water masses specific structure formation Arctic and Antarctic Seas, some temperate zone seas, freezing continental reservoirs; 7) the world ocean water salinity variation multi-millennia amplitude; 8) cryogenic and glacigenic adjusting of the gas change in ice-atmosphere systems; 9) glacigenic aerosols formation; 10) the biogenic

and organic substances internal reservoir turnover intensification; 11) the photosynthesis in ice and under ice; 12) the combined influence of glacigenic physical, physical-chemical, biochemical and biological processes on ice and water ecosystems state and structure.

The principle has been suggested: geological geophysical and geographical conditions of ice massif formation predetermine their participation in biosphere turnover of substances, energy and information. The turnover intensity can be compared with the intensity of many anthropogenic processes. The given investigation has permitted to base and single out the structural-functional category - the cryobiosphere.

The Sources, Entrance Ways and Mechanism of the Biogenic and Organic Substances Composition Formation in the Amur River Water Masses

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In the course of the last decades the biogenic and some organic substances concentration increases steady in the Amur River water, especially that of nitrogen and phosphorus compounds and phenols. The concentration reaches the greatest value at freeze-up. The phenomenon is caused by the impact of economic activities on natural processes, land, water, ice objects on the Russian and Chinese banks of the frontier river. The pollution has much to do with the atmosphere, hydrosphere, pedosphere and cryosphere. The biogenic substances are transferred from the atmosphere to the Amur water and ice core immediately with the atmospheric precipitation and by way of anthropogenic aerosols dry sedimentation. The biogenic and organic substances greatest quantity gets to the Amur channel waters from the effluents, the Sungary river in particular, and with shallow-soil waters during the rains and snow cover melting. The untreated and badly treated industrial and agricultural sewage plays very important role as the source of organic, nitrogen, silicon and phosphorus compounds. Many organic substances are represented by oil-products, which pour out on the river ice cover, used as winter roads.

The snow cover, forest bedding, bog soils, underground waters play big role as sources of biogenic and organic substances concentrations formation. The biogenic and organic substances composition forming mechanisms are:

1) dissolution and leaching of aerosols;
2) leaching, washing out and dissolution (by rain and snow melt waters) of nitrogen, phosphorus, potassium, silicon, iron compounds in the soils, forest bedding, snow cover, fertilized agricultural lands;
3) cryogenic hydration and cryogenic coagulation processes in the soil in winter period which promote humus transformation and appearance of a large number of soluble organic compounds, including the fulvic acids;
4) differentiation of chemical compounds between ice and water phases at ice and snow formation and melting, migration of ice compounds into under-ice water;
5) photosynthesis processes in water masses and ice cover when biogenic substances mineral forms turn themselves into organic ones;
6) chemical and cryochemical, biochemical and cryobiochemical processes of organic compounds transformation;
7) chemical and biochemical transformation of the rubbish, dropped and washed in the Amur river;
8) dissolution of chemical compounds, contained in the river ships exhaust gasses;

9) diagenesis of the bottom sediments;
10) chemical, physical chemical, biochemical transformations of oil hydrocarbons to phenol compounds.

The Amur River contamination is uneven. Self-cleaning processes are revealed in some river sections. Many of the above-mentioned processes can be modeled. It allows to predict the Amur River Pollution State and work out the prevention measures.

The Estimation of Water and Ice Resources Transformation as the Basis for Water Economic Organization at Territory Mining Development

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Our researches were conducted in three placer gold extraction sites in the Ayano-Maiski District of the Khabarovsk Territory in the Ariavkan river watershed (the Maya River tributary, the Lena River system). Prior to the placer gold mining in the Tas-Yuryakh stream valley its length was about 1,5 km. At the deposit mining the stream water was diverted into an artificial canal, therefore its length increased almost by 1 km.

In the second case the stream length did not increase, but its waters were lost in alluvial sediments of the Ariavkan River water from diversion canals was used for washing of the gold ores from time to time. During drought season it was directed into special reservoirs. After ore washing the water with plenty of suspended moved to settling reservoirs. In the long run the water, through the system of reservoirs connected with underground's surface ways, flew into diversion canal, and then into the Ariavkan River. In the third case the water of a drying up stream was lost in the settling reservoirs and, being filtered through unconsolidated barrows flew into river by underground way. Thus, water resources condition was changed purposefully by way of formation of artificial reservoirs and waterways, accumulation of fine soil in diversion canals.

The purposeful changes were always accompanied by accompanying (spontaneous) transformations of water resources, which, as a rule, were accompanied by eczogenic geological processes: land slips in thawing barrows, formation of small mud-flows during snow melting and rains, formation of debris cones. Small reservoir formation by way of filling with water delpenings between the barrows, spontaneous formation of new streams in mountain and roadside ditches is not rare.

The upper horizons of perennially frozen ground ice veins layers are degraded at gold ore mining. Deepening are formed after ice thawing. They are composed of unconsolidated sediments, which allow filtration of surface waters and formation of new ground water sources. That is the unusual frozen-hydro-geological conditions (accompanying transformations of ice resources) are created.

The careful observations show that the purposeful and spontaneous transformations of water and ice resources result in creation of new biotopes and formation of new aquatic and riparian ecosystems. Microphytobenthos, periphyton insects occur in settling reservoirs. Ichthyofauna species can be found in waterways flowing into the main river. Various waterfowl birds live on the banks and water surface. Animal biodiversity uncharacteristic of primeval area is formed.

The research allows development of recommendations for water economy management at the ore deposit mining:

1. Reservoir construction for drinking and industrial water supply; it should be filled in September-October from local rivers, when they contain a minimum quantity of dissolved organic substances and are colorless.
2. Use of diversion canals for neutralized solutions discharge after gold ore leaching. The receipt of these waters can be carried out through the already created system of settling reservoirs.
3. Use of some settling reservoirs for domestic waterfowl birds breeding (taking into account fodder opportunities of reservoirs).
4. Use of settling reservoirs for recreation.

Surface and Ground Water Interaction and Environmental Problems in the Amur Basin

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Surface and ground water interaction in the region (the Amur basin of Russia has the area of 950 000 km2) is formed by the following factors.

1. The quantity of atmospheric precipitation is 1000 - 1200 mm in the lower part of the basin, and 400 - 500 mm in the upper part of the basin (the valley of the Argun River). In the mountainous parts of the basin precipitation are twice as much in the flat parts, 1200 and 500 mm accordingly.
2. The permafrost rocks occupy about 70% of the region. Their largest thickness is in the mountains and equals to more than 300 m (mountain ranges of Badjal, Jam-Alin, Stanovoi, and Jugdi).
3. About 75% of the region is occupied by the mountain ranges with absolute heights of 1000 - 3000 m, another part is plains with absolute heights of 50 - 300 m.
4. The Amur basin is situated in the zone of Mesozoic folding, where strongly folded structures are well developed (they consist of sandstones, siltstones and schists). These are anticlinoria and synclinoria. Mesozoic-Cenozoic depressions and troughs are among them. They are presented by sandstones, sands, gravels and shingles, which are intramountane artesian basins in hydrogeological aspect.

The following maps have been composed for the region in scale 1: 2.500.000: the map of the hydrogeological division into districts, the map of the types of the hydrogeological systems and fresh ground waters use, the map of water horizons and complexes, the map of fresh ground water occurrences, the map of sufficiency of water-supply and water use, the map of ground water defending (ecological danger) and pollution, the map of the estimation of the ground water role in ecosystems, the map of anthropogenic transformation of ground water.

The river flow in winter period has 1 - 0.5 % of annual flow and many rivers, even with the basin of 5000 - 10000 km2, have only an underflow. Especially it takes place in northern parts of the basin. However ground water, especially in intermountain artesian basins have lots of resources. Here, the yield of wells may be 20 -50 l/s. The pollution of water resources of the region is local, because the region is poor populated. The places of such pollution are cities: Khabarovsk, Komsomol'sk-na-Amure, Amursk, Blagoveshchensk and others, and also ore mining enterprises of gold, silver, wolfram, lead and zinc.

Microbiological Indication of Phenol Pollution in Sea Water

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Mechanisms of natural and anthropogenic phenol compounds receipt by coastal ecosystems are considered. Phenolresistentic microorganisms as indicators of local and chronic pollution are used. An estimation of phenol compound transformation character is given: complete detoxification or accumulation of more toxic transformation products. The potential danger of products of these compounds destruction can be connected not only with microbiological degradation, but also to self-oxidation and condensation of intermediate products. In water with phenol pollution accumulation compound: acetone, methanol, propanol, isobutanol, acetic aldehyde et al. Special conditions for phenol compounds destruction are formed in a mixing zone sea and fresh water. Phenolresistentic bacteria from this zone are very active. The high concentration of phenols in coastal zones does not always cause ecological danger. The natural phenol pollution is marked within macrophyte communities. Phenol concentrations exceed allowable standards 15 times there. There is a problem of natural and anthropogenic phenols differentiation. Microbiological bioindication of aromatic compounds nature is offered. It has certain advantages in comparison with chemical methods. The mechanisms of phenol transformation into non-toxic products are connected with fermentative activity of microorganisms. The bacteria-destructors help discover potential danger of phenol pollution for water ecosystems.

Ecological Situation in Far East Coastal Zone in Connection of Amur River Pollution and Sakhalin Petroleum Extraction

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Petroleum hydrocarbons toxicological impact on aquatic ecosystems is seen in all their biological elements: bacterial community structure, phytoplankton, zooplankton, algae, fish. Acuteness of ecological consequences at the northern seas petroleum fields development is obvious. The threat of ecological tragedy at Sakhalin petroleum deposits development is connected with an already existing background of diverse pollution, including pollution of petroleum and phenolic combines of various origins. A considerable contribution to pollution of the Sea of Japan, the Sea of Okhotsk coastal territories is made by the Amur river watershed runoff. Pesticides, petroleum hydrocarbons, fertilizer, heavy metals salts and other toxic compounds are introduced among other components. During the last years numerous cases of fish and water smell and taste change were noted. The fish migrated from the Amur lagoon which is the receiver of a 11 surface and river toxic compounds.

The pollution of water, bottom sediments by toxic substances in the Tatar Strait is reflected in the condition of all parts of the chain. The planned expansion of Sakhalin shelf petroleum extraction will intensify ecological threat for Pacific region. Total effect from already existing pollution with inevitable chronic pollution by petroleum (even by low concentration) will result in irreversible ecological consequences.

Change of Hydrological Regime of Rivers in the South Far East of Russia under Economic Activity

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Rivers of the southern regions of the Russian Far East undergo more intensive impact owing to the fact of using various natural resources of a territory. Changes of water and channel regimes occur, the water quality deteriorates, its turbidity is increased.

The strongest transformation of rivers occurs under mining natural resources' deposits in the valleys of rivers (gold, platinum, tin). In these cases all elements of a river are entirely destroyed. They are recovered in the course of several decades. In the regions of mining placer deposits of gold, high turbidity of water exceeding natural one 30-40 times is observed in 12-15 years after cessation of mining.

This is connected with the formation of longitudinal profile of a river and restoration of a floodplain at the expense of rewashing and redeposition of disturbed loose rocks.

Forest cutting has strong impact on rivers. Thus, for example, in Sikhote-Alin, in the regions of logging, erosion processes are activated as well as landslides most frequently become to happen. There are known cases when salmon spawning grounds have been ruined as a result of landslides. Changes of water and channel regimens of rivers under the influence of forest cutting in the territory of the Russian Far East are weakly studied.

The construction of hydropower station on the tributaries of the Amur River - Zeya and Sungari - has significantly influenced on the level regime of the Amur. As a result of it, transformation of floodplain natural complexes has begun. The construction of new hydropower stations in the middle stream of the River could significantly disturb the balance of ecosystems in its lower reach.

At present the anthropogenic transformation of rivers in the south of the Far East is characterized as a considerable unevenness. There are strongly disturbed and transformed river basins close by entirely undisturbed wild ones.

The process of anthropogenic impact on rivers is intensively developed and quite now it is necessary to create an effective net of monitoring water resources of the region.

Ecologic-Glaciochemical Parameters of Priamurie and Priokhotie Snow Covers the Basis for the Prediction of Environment Transformation at Mining and Power Development of Territories and Water Surfaces

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The long-term research into snow cover chemical composition was conducted on the Khabarovsk Kraj territory in industrial and agricultural regions, prospective power and mining development areas, on protected territories. The purpose of the research was to reveal the "background" regions, snow pollution peculiarities, direction of pollutants transfer in border regions to develop the prognoses for economic activity impact on ecosystems in winter.

The research is based on the idea that chemical composition of snow cover melted matter practically completely coincides with its soluble substances composition.

System of glaciochemical indicators was used for revealing of pollution zones and degree, evaluation of snow cover glaciochemical condition. The indicators are subdivided into indicator of natural processes (hydrological, glaciological, hydrochemical, glaciochemical) and anthropogenic processes (chemical and mechanical pollution) processes (Ivanov, Novorotskaya, Chuckmasova, 1990). The system includes such data as volumes: of Òî, mineralization, relative acidity parameter (Òî / ÒNH4), correlation coefficients between various parameters of snow cover chemical composition, fractionation factors various components background and allowable concentration balance, integral characteristics of a chemical composition acidification and oxygen biochemical consumption values, chemical composition stability or instability.
Maps of snow cover pollution are presented. The above-mentioned indicators are used in the maps reflecting continuous area pollution, local pollution zones, linear (along the communication corridors) pollution and describing pollutants genesis. Earlier established regularity on the role of forest fires in formation of high concentrations of nitrogen and phosphorus compounds, organic substance, soot particles, low volumes of Òî in snow cover (Ivanov at al., 1978, Ivanov, 1986) is confirmed. Taking into account some hydrometeorological parameters, ways of pollutant transfer have been ascertained. They are divided into local (along the Amur River valley), regional (Yakutiya - Khabarovsk Krai, the Okhotsk sea - South East continental part) and Trans border China - Russia. The received data analysis permits to predict changes of a chemical composition of snow cover and surface waters flow during spring snow melting in the large rivers watersheds and to recommend measures for water purification for industrial and domestic water-supply.

Biogenic Pollution of Amur River Water

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Hydrochemical investigations of the Amur River, which have been carried out on a site from the confluence of the Sungary River to the estuary of the Amur River (1300 km) during the past few years, show strong biogenic pollution of the Amur waters. During the summer and autumn low water period and during floods originating in Russia, this pollution is manifested by "blooms" in the Amur River and in lakes connected to it by channels. In lake water the pH reaches 9.3, and concentration of HPO_4^{2-} and NH_4^+ is 4.2 and 1.2 g/m^3 respectively. Floods formed in the Sungary basin carry elevated quantities of biogenic substances into the Amur River. In 1998 such a flood resulted in high concentrations of NO_3^- and HPO_4^{2-} up to 4.7 and 0.34 g/m^3 respectively, and discharges of 0.25 and 9 thousand ton/day respectively at Khabarovsk. The duration of this flood (>3 months) suggests that Amur water quality will deteriorate in the future. During the winter low water period the biogenic pollution is characterized by a high (>1.0 g/m^3) concentration of NH_4^+. In January 1998 it was 1,45 g/m^3, and the discharge was 250 ton/day at Khabarovsk. Biogenic substances originating in China, whose economy has been developing during recent years, cause such strong pollution of the Amur River.

Runoff of Dissolved Substances in the Amur River During the Winter Low Water Period near Khabarovsk

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A study of the runoff of the dissolved substances in the Amur River during the winter low-water period at Khabarovsk between 1951 and 1998 reveals large changes connected with the installation of the Zeya hydroelectric plant on discharges and water pollution of the Sungari river. Before construction of the Zeya hydro-unit (1951-1978), an average weighted value of mineralization of the Amur water was 122.6 g/m^3, and the discharge of dissolved substances was 9,152 ton/day. With construction of Zeya hydroelectric plant (1979-1988), Amur River water discharge has increased insignificantly, while an average weighted contribution of mineralization by the weakly mineralized Zeya waters decreased to 769 g/m^3, and the runoff of dissolved substances fell to 6722 ton/day.

During the most recent years (1997-1998) the increase of Amur discharges in the winter low water period was accompanied by an increase in dissolved substances by a factor of more than two (up to 18,179 ton/day). The average weighted mineralization value was 94.7 g/m^3. Such an increase in the mineralization of Amur water is caused by the input of more mineralized waters from the Sungari river (upstream of the Sungari confluence, the concentration equals 50 g/m ^{3}, and downstream it is 120 g/m^3). The difference depends mainly on anthropogenic components of the Sungari water, i.e., increased concentrations of Cl^- up to 11.7 g/m^3, Na^+ up to 9.2 g/m^3 and SO_4^{2-}, 16.0 g/m^3. Upstream of the Sungari confluence, the concentrations of the above named ionic species did not exceed 1.9, 2.6 and 4.7 g/m^3, respectively. The anthropogenic component of the Cl^- runoff of the Amur River at Khabarovsk has increased by 50%. The increase of the discharge of dissolved substances in the Amur River in recent years is connected with the growing anthropogenic impact in the Sungari basin.